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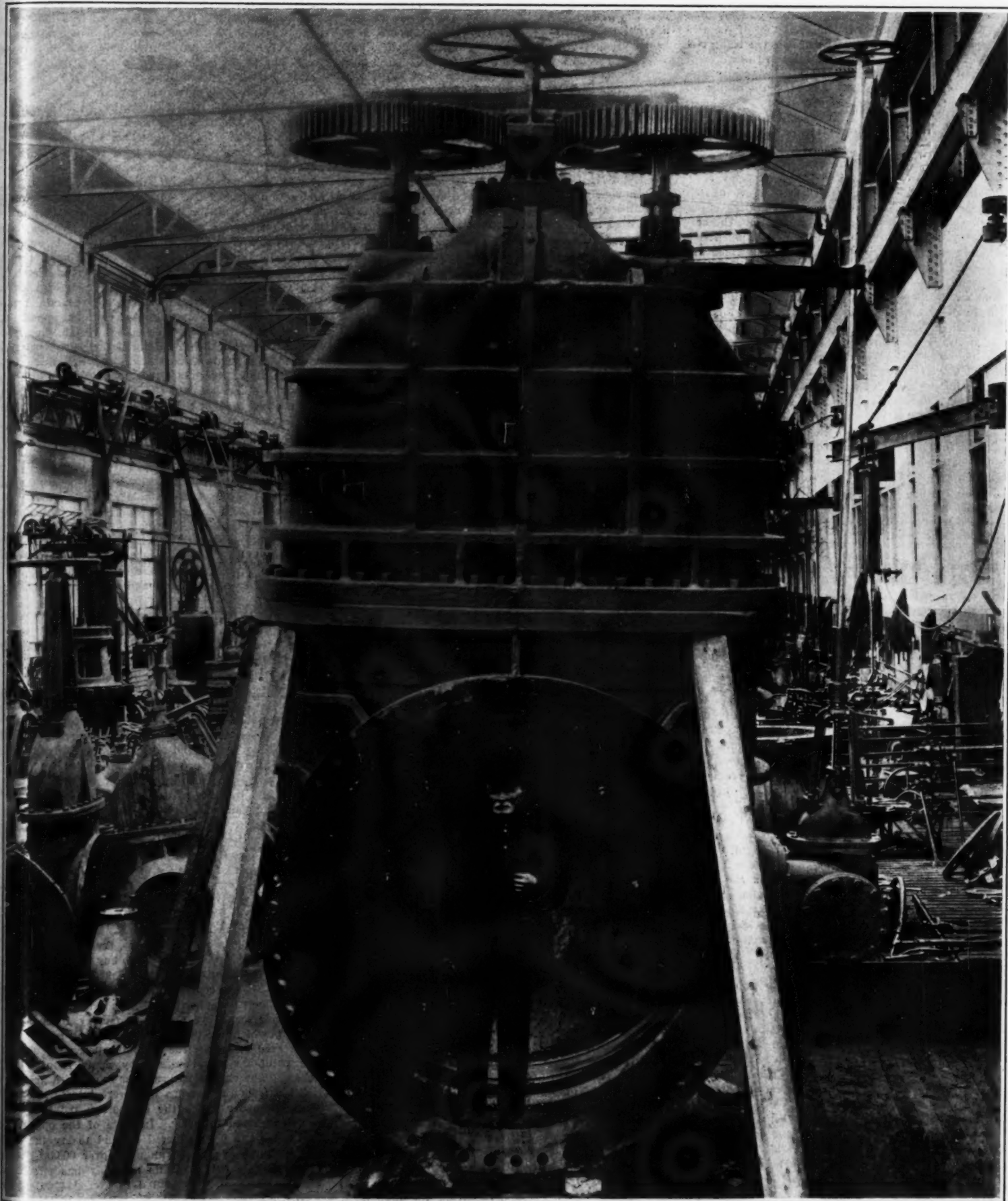
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This mammoth gate valve weighs 50,000 pounds.

LARGE GATE VALVES AND PUMP FITTINGS.—[See page 367.]

Modern Painting Methods in the Navy*

The Government Now Its Own Manufacturer of Paints

By Henry Williams

THE considerations that lead to the use of paint on steel ships are the same in general as those necessitating its use on steel structures on shore. The conditions on ships, however, necessitate more urgent measures for preserving their structures. Corrosion of the steel in ships proceeds more rapidly than on shore and might result, if neglected, in the total loss of the vessels. Sea water, which contains in solution many elements, probably is the strongest corrosive agent with which large quantities of structural steel comes into contact. It, and the moisture from it, serve to set up the electrolysis necessary for corrosion. The black oxide mill scale, which is on all structural steel, unless special precautions have been taken to ensure its being removed, is electronegative to the steel and the corrosive action of the sea water is stimulated by its pressure.

To a person not familiar with the effect of sea water on steel work, its power of disintegrating is not always apparent. It is so much greater than the corresponding action of fresh water that, by comparison, the latter may be neglected, and steel ships which are laid up in fresh water basins require little attention to prevent corrosion of their outside bottom plating.

Another characteristic of sea water, which it shares with fresh water, and which unfortunately has not been taken into account, is its action on those paints most generally used on shore and which are made up with linseed oil as a vehicle. Not being a chemist I will not attempt to explain this action beyond saying that the linseed oil film becomes softened by the action of the sea water and the paint ceases to protect the steel under it. As stated, this important defect of linseed oil paints has not been recognized generally either in the navy or the merchant marine, and such paints continue to be applied on steel in locations exposed directly to the action of salt water. Although there are many damp-proof and water-proof paints made commercially, their advantages do not seem to have been pointed out with sufficient clearness and force to bring about their general adoption for ship use.

Experience, however, has taught ship owners the world over that they must take energetic steps to prevent deterioration in protecting from corrosion the steel of their ships by the free use of paints, varnishes or cements. Naval vessels have an additional consideration for the use of paint in their desire and the necessity for neatness and cleanliness beyond that achieved ordinarily on vessels of the merchant marine.

Thus paint for the navy is an important subject, and its importance may be pointed out in a striking way by considering the amount and cost of paints used in some cases. During the construction of the 22,000-ton battleship "Florida," up to the time of first commission there were used a total of about two hundred tons of paint and varnishes. Of this amount, about one hundred tons was red lead paint used to protect the steel from corrosion, principally as priming coats, though in some cases it was used alone on the steel work, no finishing coat of paint being necessary. The total cost of all paint and varnish used, including the labor of preparing the surfaces and applying the paint was over \$150,000. It should be borne in mind that this amount represents the first painting costs, the value of paints and varnishes used annually by a battleship of this size for keeping the ship painted, exclusive of cost of applying it, is not far from \$15,000.

The above will serve to give weight to my statement that to the navy, and to the merchants who make a business of supplying painting materials, the general questions of paint used by the navy, the kinds of materials used, the methods and frequency of application are of vast importance and deserve much more attention than they have received. The chemists who make it their business to determine the qualities and characteristics of paint materials could render an important public service by investigating the subject along scientific lines and telling those of us who are concerned with the use of the paint what are the considerations affecting its choice and what materials can be expected to give best service in the various locations on shipboard. This has not been done heretofore, and shipbuilders use continually paints that not only are not the most suitable but that often serve no useful purpose and even stimulate corrosion. Many such

examples could be cited, the most striking being the general use of linseed oil paints alluded to above, red lead paint being used perhaps most often in locations for which it is essentially unfit.

The policies of the Navy Department in the use of painting materials are very conservative and changes are not made readily. The responsible officials must be convinced that changes are desirable and in the interest of efficiency. Such conviction can be carried only by demonstration of superior merit in actual tests, which are scrutinized by person generally not ready to be convinced easily. These tests of paint are made usually by application on a ship, and the determination of comparative results by the same persons is not always possible, due to the removal of the ship to another station. This renders the decision dependent upon the observation of persons who may not be competent to decide and who are frequently not interested in the conclusions. Such tests naturally require several years to produce results and shifting personnel in the interval often nullifies the conclusions reached. The above should serve to indicate the difficulties attendant upon changes in the Navy Department's policies as regards the painting materials and methods prescribed for naval vessels.

In the purchase of its paint supplies, which exceed in value annually over one half a million dollars, the Navy Department makes use of specifications worded accurately to require in most cases the highest grades afforded by the market. Careful inspections and tests are made in most cases to insure that the materials accepted are as specified. Many of the characteristics mentioned in the specifications no doubt are not essential to the purposes for which the materials are used and manufacturers often have seemingly just ground for complaint in the rejection, for technical deficiencies, of materials which they feel assured would answer fully all practical needs. On the other hand it must be remembered that there are very few authoritative data as regards paint materials and on which specifications may be used. The naval authorities consequently have been forced to draft their own specifications, and apparently they have erred only in doing their work too well and in not accepting changes in ideas until there was in their opinion ample assurance that such changes met with the approval of the trade generally. For this reason some of the navy's paint specifications have not been changed in many years. The navy has inherited the traditional conservatism of the practical painter and for many years adhered to the old and staple paint materials, such as red lead, white lead, white zinc, pure linseed oil and pure turpentine. This fact long has been used as an argument against the newer paint materials. Many manufacturers regard the navy trade so highly as a recommendation of their products that they are willing often to sell them at a slight loss to insure receiving the contracts, as the care exercised by the naval officials is accepted by the public as an index of merit of those materials that are purchased and accepted. The fact that the Navy Department requires the use of certain paint ingredients doubtless has influenced many ship owners and others to purchase and use the same materials.

In the past five years the naval authorities have awakened to the advances that have been made in the paint trade and have taken some progressive steps, with others in contemplation, and promise to place themselves in the ranks of the progressive paint users.

One of the most important advances in recent years was the change from the custom formerly in vogue of issuing to each naval vessel its paint in the form of the raw ingredients, which then were mixed on board ship by hand as required for use by the ship's painter. Now paint, mixed and ready for use after stirring, is issued. This change was one of the most important and far reaching in its effect that could have been taken. It recognizes primarily the superiority of the compound paints made by machinery according to certain definite formulas over that mixed at haphazard according to the whim of the comparatively ignorant painters on the ships. This, however, was not the most important consideration in making the change. It was recognized that the cost of the navy's paint could be reduced, without impairing its quality, by using some of the newer paint materials. This would not have been possible had the ingredients been issued to the painter, for they would have been condemned before even tried. As it stands, paints have been made

up, issued and used with good results on naval vessels, which contained such ingredients as blanc fixe, barytes, silica, lithopone, petroleum thinners, China wool oil, fish oil, soya bean oil and other materials that many persons regard as rank adulterants. The fetish which binds seafaring men to the use of red lead linseed oil paint has been discredited and paints which cost much less giving better results are being used extensively in its place.

The most important of the changes in materials, that has been made up to the present time, is the discontinuance of the use of turpentine as a thinner for paints. This change was made after full investigation and consideration of the question in all its phases. During the year 1910 the navy purchased over 70,000 gallons of turpentine at an average cost per gallon of over 78 cents. Early in 1911 the change was instituted and now a hydrocarbon spirit made from petroleum is used almost exclusively for thinning paint. This important step no doubt has had an influence on the trade in general, and it is to be hoped that it will serve to reduce the total consumption of turpentine and tend to a conservation of the pine forests being destroyed by the turpentine people to meet the fancy of painters who think it is essential to make good paints and varnishes. This change was not made without opposition, not only from the turpentine manufacturers, but from within the service itself. Many of the master painters in the navy yards attributed to the turpentine substitute faults in the paints that were shown readily to be due to other causes. The ships' people opposed it because they thought that, as the paints issued to them cost less as a result of the use of the substitute, they were consequently less efficient.

Another innovation that has been made is the introduction, for use preliminarily on one division of the battleship fleet, of a slate color outside paint, having its pigment made of zinc oxide and blanc fixe, with necessary tinting materials. This paint is intended to supplant the lead and zinc paint slate color used for many years; on tests which have been extended over more than one year it has shown excellent resistance to the action of salt water, while costing about 35 cents per gallon less than the lead and zinc paint.

Another question affecting paint that has been engaging the attention of the naval authorities recently is lead poisoning as caused by the use of lead paints. There have been a number of cases not only among the navy yard workmen, but among the crews of the ships. Many of the spaces on shipboard are so confined, and men scaling off old paint or applying new paint come into such close contact with it that they are susceptible especially to lead poisoning. It is regarded as being probable—though the number of well defined cases of plumbism is comparatively small—that there are many persons who suffer from liver trouble, more or less acutely, as a result of absorption of lead by their systems, due to the exaggerated use of lead paints on shipboard.

In closing I cannot refrain from making mention of the situation as regards shipbottom paint in the navy. As may be understood readily, the navy is a large consumer of this class of paint. For many years it purchased its supplies from various firms, who manufactured under trade names and secret formulas, and who claimed wonderful properties for their products. They affected such a great mystery as to the ingredients and methods of manufacture, that for many years it was assumed to be necessary to buy shipbottom paint and pay the exorbitant prices asked. Consideration finally led to the conclusion that perhaps it would not be so difficult to make the paint and, after experimenting a number of years, a satisfactory formula was evolved, which has given most excellent results, and has served to reduce the annual expense for shipbottom paint for naval vessels by many thousands of dollars. The change naturally has met with great opposition from the persons who were interested in the contracts under which the shipbottom paint supplies were purchased formerly. In spite of the opposition, the policy has been adhered to, and to-day the navy manufactures at Norfolk annually over 60,000 gallons of shipbottom paints. This not only has effected a considerable saving, estimated to exceed \$100,000 annually, but the practical results obtained in preventing the fouling of the bottoms of the ships are uniformly satisfactory, which is more than can be said of the results obtained from the paints that were purchased formerly.

* Paper presented to the Eighth International Congress of Applied Chemistry.

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The Optics of a Railway Signal Lamp*

• Why is the Lens Made of Corrugated Glass?

By T. A. Lawes

SPHERICAL ABERRATION.

THE FORMS of lenses in common use in signal lamps are shown in Figs. 1, 2, 3, 4, 5 and 6. Fig. 1 is a lens now seldom seen in railway practice, being supplanted by others more perfect in form and lighter in material. The law for the survival of the fittest here prevails, as in the animal or vegetable kingdoms.

Fig. 1 is deficient in this particular: Parallel rays of light nearest the axis of the lens are refracted to a focus more remote from the lens than those which are incident at a distance from the axis of the lens.

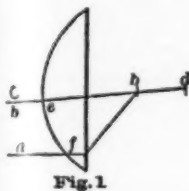


Fig. 1

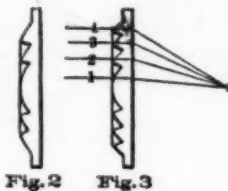


Fig. 2

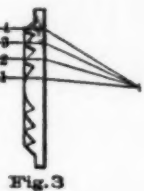


Fig. 3

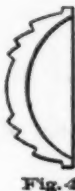


Fig. 4

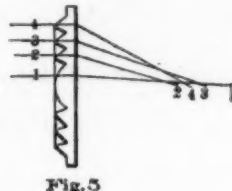


Fig. 5



Fig. 6



Fig. 7



Fig. 8



Fig. 9

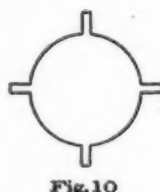


Fig. 10

In this lens, either by experiment or projection of the rays of light, the ray *a* will meet the axis at *b*, and the ray *a* at *d*. The distance *b d* is called the spherical aberration, and in this form will amount 117/100 of the thickness of the lens. As the central parts of the lens refract the light too little and the outer parts too much, it is clear, if we should increase the convexity at *e*, and decrease it at *f*, we should remove the spherical aberration. The ellipse and hyperbola are curves of this kind in which the curvature decreases from *e* to *f*, but while a lens of this form is perfect, yet the great difficulty of making these curves has prevented its introduction. Corrugated lenses, invented by Fresnel, are the forms in general use, and in comparison with the plano-convex, can be made much lighter, and the spherical aberration corrected by making the foci of each zone coincide, as in Fig. 3, in which the rays of light coming from the focus are refracted into parallel lines; and by the law of conjugate foci, the reverse holds true, namely, light falling on the lens in parallel lines is refracted to a focus. To determine experimentally if a light falling on a certain lens was refracted to a focus free from spherical aberration, a series of opaque diaphragms were used, so arranged that zones 1, 2, 3, 4,

is turned to the sun, and the sliding piece moved to and fro until a clear image is obtained. The distance *d* is noted: the diaphragm, Fig. 7, is removed, and Fig. 8 put in its place and tested, the distance *d* is noted, and so on, until all the zones are tried. Fig. 5 shows the aberration of a certain lens as found by this instrument.

PURITY OF THE GLASS.

The comparative purity can be tested by observing the appearance of a black line upon white paper, when the lenses to be compared are laid upon it. The lens that shows the darkest line is the one made from the purest glass. Care should be used in this test, that the edge of lenses only be used, as they have parallel sides for a short distance. This can be done, and any error arising from the different curvatures be avoided. Fig. 11 shows the position of the lenses in regard to the black line.

PHOTOMETRIC TESTS.

In my first photometric experiment, the method of comparative shadows was used as devised by Rumford, but was finally abandoned in favor of a photometer invented by Bunsen. Rumford's photometer on account of the different sizes of shadows, makes it difficult to decide when they are of equal intensity. Bunsen's being used on a different theory, practically easy to

manipulate, and at the same time accurate, led to its adoption over other forms of photometers in use. My photometer was made of pine wood. See Fig. 13. The strip *A* is ten feet long. *B* is a paper screen on a sliding piece of wood. *C* is a lamp so arranged that lenses can be introduced quickly. *d* is a sperm candle used in these experiments as a standard of comparison. The paper screen is glued upon the sliding piece while wet; when dry, it becomes tight like a drumhead. The aperture in *E*, over which the paper screen is placed, is 8 inches in diameter; in the center of the screen a grease spot is made about 1/2 inch in diameter.

This is best made with spermaceti dissolved in naph-

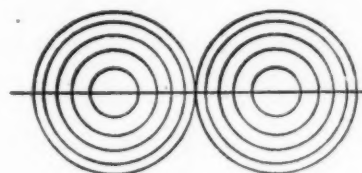


Fig. 11.

tha. The theory of the spot is this: The spot allows more light to pass through it, and consequently reflects less than the unstained part of the paper: If, therefore, the paper be illuminated more strongly from behind, it appears bright on a dark ground. On the other hand, it appears dark on a white ground if it be more strongly illuminated on the front surface; while with equal illumination the spot becomes invisible, since it cannot then appear either darker or lighter than the adjoining paper. The lenses are tested by moving the candle until the grease spot disappears. The distance *e* is noted for each lens under consideration. They are to be compared with each other inversely as the square of the distance *e*.

The apparatus used by me in testing did not cost over \$3, being made principally from pine wood, utilizing an old switch target lamp to hold the lenses in the photometric tests. While the cost is but small, the satisfaction is great. Where uncertainty before existed, no obstinate doubt remains after such tests.

RESULTS.

1. It has been found by means of these tests that lenses from the same makers often vary 7 per cent in their transmitting power, although to the eye they appear apparently similar.
 2. Lenses by different makers vary as much as 50 per cent in light transmission.
 3. Certain lenses were so deficient that the outer zone could be stopped out, and the quantity of parallel light transmitted would not be affected thereby.
 4. A removal of the flame 1/2 inch from the focus reduced the light in one instance 20 per cent.
- Always have the flame in the focus, if the best results are wished for.

* Reproduced from *Railway and Locomotive Engineering*.

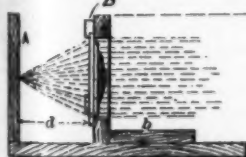


Fig. 12.

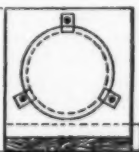


Fig. 13

The Use of Sulphur Dioxide in the Manufacture of Wines

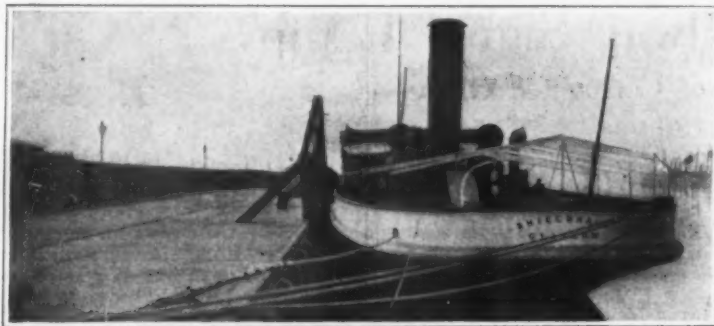
The justification of the use of sulphur dioxide (sulphurous acid) in preparing wines is one of the subjects which was brought before the recent Congress of Applied Chemistry. P. C. Rossi quotes the following expert opinion given to him by Frederiek T. Violetti in regard to this subject: "The judicious use of sulphurous acid, whether in the form of sulphur fumes, potassium meta bisulphite or the liquefied gas during and before fermentation, has resulted in great improvements in the quality of all wines and has greatly diminished the amount of spoil and unwholesome wine which was formerly made. On this point, all expert wine-makers and all competent enological investigators agree. While there is less danger of the complete spoiling of sweet wines by injurious fermentation than there is of that of dry wines, imperfect fermentations often much deteriorate their quality. Volatile acids, persistent cloudiness, unpleasant flavors and odors, are caused principally by the development of bacteria, molds and wild yeasts. Much of this damage may occur during

the first stages of fermentation in sweet as in dry wine. There is no method known to practice or science of effectively preventing these defects without introducing others except the accurate and careful use of sulphurous acid. Much of the opposition to the use of sulphurous acid on the part of those unfamiliar with the theory and practice of wine-making comes apparently from a misconception as to its object. Sulphurous acid is not used by the wine-maker as a preservative. The amount necessary for this purpose would be sufficient to completely spoil his wine and to render it unmarketable.

Used properly, it is no more a preservative than the steam he uses to clean and sterilize his barrels. Wines properly fermented by the use of minute but accurately measured amounts of sulphurous acid have superior keeping qualities but not because of the presence of sulphurous acid. This, in the finished wine, has in great part disappeared and what remains has entered into innocuous combinations and lost its antiseptic properties. Such wines keep better because the yeast has done its work better, and has utilized the sugar, albuminoids and other matters acted upon by micro-

organisms to produce substances of value, and not deleterious to the wine, as are those produced by the other organisms which would have developed had no sulphurous acid been used."

Preservation of Rubber Articles.—Rubber articles that have become hard recover their elasticity in a short time if placed in 3 per cent carbolic water or 3 per cent aniline solution. In the case of the carbolic solution it must not be forgotten that black goods exposed to it become grey. If it is desired to preserve the black or red color of the goods, that, too, can be done. A one per cent solution of pentasulphate of potash is employed. It is true that this smells dreadfully but the restoration of elasticity is quite considerable. Experiments with glycerine and water, in equal parts, as regards simple preservation, gave excellent results, says *Das Rezept*. The goods remain perfect for a long time but old goods are not restored to usefulness. Least satisfactory was the proposition by Berg, to preserve the rubber goods in lime water; if effective the vessels would have to be closed air-tight. In open vessels the lime settles and the solution molds.



The Steamer Shieldhall, Which Transports Glasgow Drainage to Sea.



Gage Weir on the Effluent Channel of the Shieldhall Sewage Works.

Glasgow Main Drainage Scheme

One of the Largest Installations of Its Kind in the World

By Hon. Frank I. Cohen, Master of Works, City of Glasgow

From my own observations I notice that the drainage of your eastern capital is not what it ought to be, as it flows into the rivers on both sides of this large city and adjacent to the public baths and ferries. I am at a loss to understand why the taxpayers of New York city should allow this to continue longer, as it pollutes the water and is bad for the health of the inhabitants.

Prior to the year 1904 the whole sewage of Glasgow was discharged without any form of purification, into the River Clyde.

The Main Drainage Scheme for the collection and treatment of the sewage of Glasgow and the adjacent local authorities was authorized by special statutes of 1891, 1896, 1898, 1901, 1903, 1904 and 1907. Next to the undertaking of the London County Council, the Glasgow Main Drainage Scheme is the largest in the world. It stretches along both sides of the River Clyde for a distance of about 15 miles, limited by the Wilderness of Cadder on the north and the borders of Mearns Moor on the south, and extending westward from the Bishop Loch, in the ancient Regality of Glasgow, to the Duntocher Burn, within the Earldom of Lennox, the superficial extent of the drainage area being 41½ square miles. The territory may hereafter be increased by the inclusion of other areas belonging to local authorities.

The volume of sewage and the proportion of rainfall to be dealt with, which will originate within the indicated drainage area, and which will be treated in the three separate works described, is estimated on the ultimate development of the whole territory, at 250 million gallons per day.

The drainage area is divided into three distinct sections, each having separate sewage disposal works.

The works for the treatment and disposal of the sewage of this area are situated at Dalmarnock, and the sewage is conveyed there by a main sewer and various connecting sewers, constructed at the cost of the Caledonian Railway Company, according to a scheme devised by Mr. McDonald in association with the late Sir Joseph Bazalgette, during the temporary disablement of the late Mr. John Carrick, Master of Works.

The works for the disposal of the sewage derived from this area are situated on the river bank at Dalmuir, about 7 miles below Glasgow.

The works for the disposal of the sewage of this area were originally intended to be situated at Braehead, about a mile eastward from Renfrew, but as this disposition was found to be disadvantageous to the trustees of the Clyde Navigation, it was arranged to place the works at Shieldhall.

The different works authorized by the statutes of 1891, 1896, 1898, 1901, 1903, 1904 and 1907 are statutorily regarded as one undertaking.

The collecting and intercepting sewers which connect

with the Dalmarnock Works have been in successful operation since May, 1894.

The daily volume of dry-weather sewage treated there at the present time is about 20 million gallons.

The purification of the sewage by chemical treatment at the Dalmarnock Works was viewed as an experiment. The results proved so satisfactory that it was resolved in 1895 to proceed on similar principles with the works for dealing with the areas included within the remaining territory; Mr. McDonald being then appointed engineer.

The daily volume of dry-weather sewage to be ultimately treated at Dalmuir is 49 million gallons, the present volume being 37½ million gallons. The corresponding volume at Shieldhall will be 47 million gallons, the present quantity being 31½ million gallons.

The collection of the 96 million gallons of sewage within this divided territory involved the construction of 30 miles of main sewers, differing in diameter from 2 feet 6 inches to 10 feet, varying in level from 4 feet above the surface to 50 and 60 feet below the ground, with gradients varying from 1 in 25 to 1 in 2,810, and passing under lines of railway in no fewer than 30 places.

The flat gradient suggests sluggish flow, but it is satisfactory to record that the computed velocity of 3 miles per hour has on many occasions been attained.

The areas dealt with are drained on the combined system; that is to say, the sewers convey not only the dry-weather sewage, but also the storm-water discharge from these areas during the periods of rainfall.

Physical and financial reasons make it possible to construct sewers in urban districts of such dimensions as will carry off the whole volume of sewage and rainfall during periods of storm. The sewers have therefore been designed of such capacity as provides for the daily delivery of a quarter of an inch of rainfall in addition to the ordinary dry-weather flow of sewage making a total volume of 216 million gallons of combined discharge at Dalmuir and Shieldhall.

The most eminent authorities, who in the past advised the Corporation of Glasgow, adopted the figure of a quarter of an inch of daily rainfall as the maximum that should tax the capacity of a main sewer. Sir John Hawkshaw, Sir Joseph Bazalgette, Mr. Bateman, and Sir Alexander Binnie employed this figure in the numerous important drainage undertakings with which their names are associated.

Regulating valves, placed on the connections between the street drains and the main sewers, control the admission of this proportion of the rainfall; any excess passing to the river as at present. When usual conditions necessitate the admission of a larger volume of rainfall, arrangements are provided at convenient intervals for relief, either by means of the street sewers or of specially-constructed channels.

Wherever the street sewers are thus made available for the relief of excessive rainfall, they are protected on the river side of the low-level main sewer by balanced tide flaps, which prevent the regurgitation of river water during ordinary weather.

The discharge action is entirely automatic and its working has up to the present time proved in every way satisfactory. The system was subjected to an unusually severe test during the great floods that occurred on the 17th of March, 1906, when the records of the University show that upwards of an inch and a half of rain fell within twenty-four hours, but no complaint from any source was received of any failure in the carrying capacity of the intercepting or outfall sewers.

One of the principal features of the Western scheme is an outfall sewer conveying the drainage of Springburn.

The low-level sewage of Glasgow and Patrick is raised into the outfall sewer at Patrick Bridge Pumping Station, the lift being 37 feet 6 inches. The engines, three in number, are of the triple-expansion inverted marine type, with plunger pumps, each capable of raising 11,250 gallons per minute, or 16 million gallons per day. Steam is supplied to these engines by four boilers, working at a pressure of 160 pounds per square inch.

The Clydebank sewage is pumped at Dalmuir, the lift there being 21 feet. The pumps at Dalmuir are of the centrifugal type, all the power for the sewage treatment plant being transmitted by electricity, generated at the works.

The sewage arriving at Dalmuir first passes through screens and then enters a catchpit, where all floating materials and detritus are effectually removed. Thereafter the sewage flows into precipitation tanks at a level of about 4 feet 6 inches above high tide.

The low-level sewage from Clydebank is also screened before it is pumped into the catchpit. Within the catchpit, which is 156 feet long, 24 feet wide, and 18 feet deep, all sand, grit, detritus, and other matters that have not been intercepted by the screens are precipitated by their own weight and then removed by a traveling dredger and placed on railway wagons for disposal. Within the catchpit the sewage receives the necessary proportion of chemical ingredients before passing out through the feed channels into the precipitation tanks, which are worked in series, on the principle of under-surface continuous flow. A variation of the system employed at Dalmarnock has been adopted at Dalmuir, an oxidizer plant having been installed for the production of persalt of iron, as a precipitating agent, in place of sulphate of alumina. This change of treatment has proved both economical and successful.

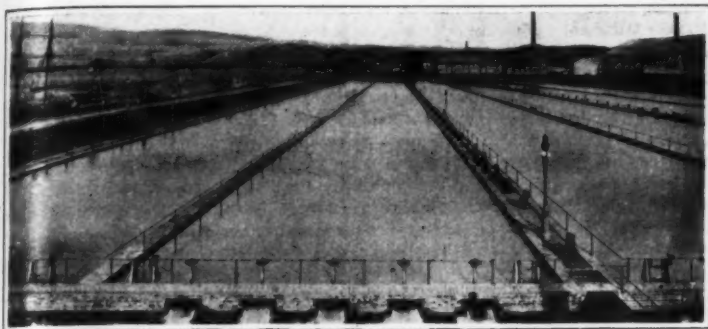
The final process of sewage purification is effected in a series of eight precipitation tanks, each parallel with the



Feed Channel and Precipitation Tanks of the Dalmuir Sewage Works.



Precipitation Tanks of the Shieldhall Sewage Works Viewed from the West.



Precipitation Tanks, Showing Discharge Into Effluent Channel at Dalmuir.



View of the Effluent Channel of the Dalmuir Sewage Works.

other, and each 750 feet in length. The purified effluent, passing from the tanks, is delivered into a wide channel at the lower end of the tanks, and, after passing over a gauge weir, is discharged into the river by means of six overflow pipes, which are protected against regurgitation by balanced tide flaps. A relief sewer for extraordinary rainfall is carried directly from the catchpit to the Duntocher Burn.

The sludge gravitates into underground channels, from which it is pumped into storage tanks, and is thence delivered at arranged intervals to a specially-designed sludge steamer, with a carrying capacity of over 1,000 tons, and conveyed to sea.

A protective embankment has been raised at the south end of the works, to a level of 3 feet above the highest recorded flood tide.

The general arrangements of the Dalmuir and the Shieldhall Sewage Works will be seen in the accompanying illustrations.

The working of the Western Sewage Works has in every way answered the expectations of the Sewage Committee and the Corporation, and has brought about an unmistakable improvement in the condition of the river.

The works for the purification of the sewage of the southern area are situated at Shieldhall, and the methods

of the southern sewage, have, like those at Dalmuir, the great advantage of river frontage, with every facility of water carriage for receiving and despatching materials. A separate sludge steamer, designed to carry 1,500 tons of sludge, has been placed on this situation.

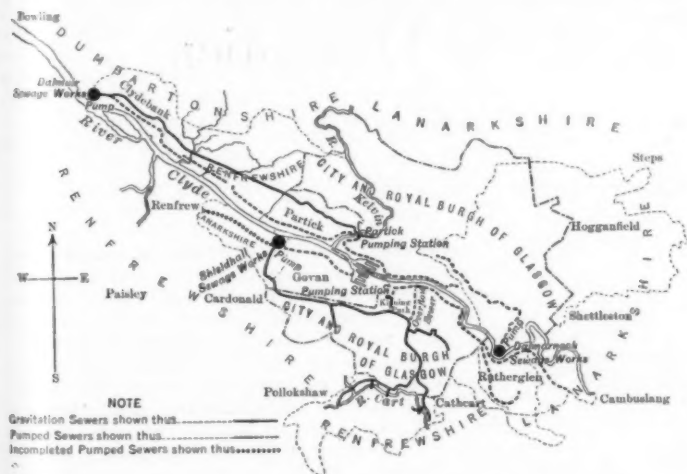
The system of treatment adopted at Dalmuir is chemical precipitation and under-surface continuous flow. The sewage received at the works is most complex and intractable, consisting principally of industrial refuse, carrying suspended matters that vary from 20 to 1,000 grains per gallon. The treatment of such sewage is a matter of no ordinary difficulty, and the proportion of the chemical ingredients undergoes frequent change during the day.

After careful deliberation, and much patient inquiry on the part of the Sewage Committee and their advisers, as to the action of other municipal authorities in England, it was resolved to adopt at Dalmuir and Shieldhall the method of treatment by chemical precipitation which had been in successful use at Dalmuir, with this variation: that the sludge presses, which by compulsion of circumstances are employed at Dalmuir Works, are dispensed with, and the precipitated sludge, without undergoing pressure, as already explained, is carried out to sea. When this method of conveyance was recommended by a special sub-committee of the Sewage Depart-

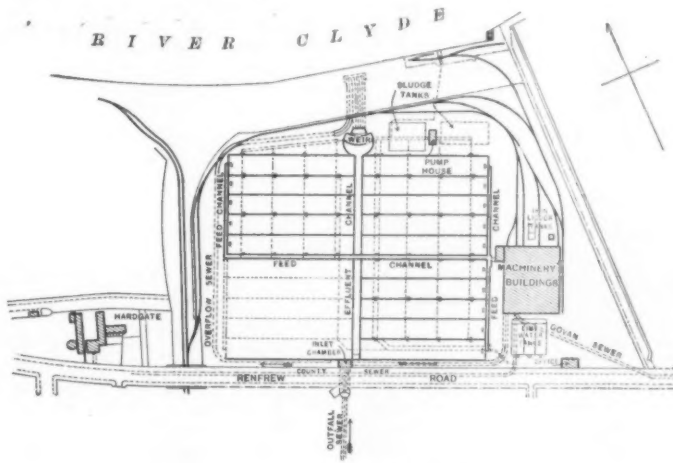
ment, who had seen what had been done in this way with the most satisfactory effect by the London County Council, it was predicted that the economical results achieved by that body on the Thames would at least be equalled by the Sewage Committee on the Clyde. This prediction has been more than vindicated. Without the slightest disparagement to the very able advisers of the London County Council, it may be mentioned that the cost to them of recovering and dispatching their sewage sludge, as stated in their present accounts, is 6½ pence (about 13 cents) per ton, as contrasted with the Glasgow figure of 2¼ pence (about 5½ cents).

Before commencing work at Dalmuir, numerous suggestions were made to influential members of the Sewage Committee and the Town Council, urging a change of system in the direction of bacteriological methods of sewage purification. These were duly considered, but the most diligent inquiry regarding the means adopted by other authorities of various places in England failed to provide the Sewage Committee with any reason for departing from what they justly considered a securely ascertained and efficient system of sewage purification and disposal.

The installation of a special experimental plant for the bacterial treatment of sewage at Dalmuir gave satisfactory results, but also corroborated the information



Map Showing Different Sections of Glasgow Drainage Scheme.



Plan of Tanks and Outlet Works at Shieldhall.

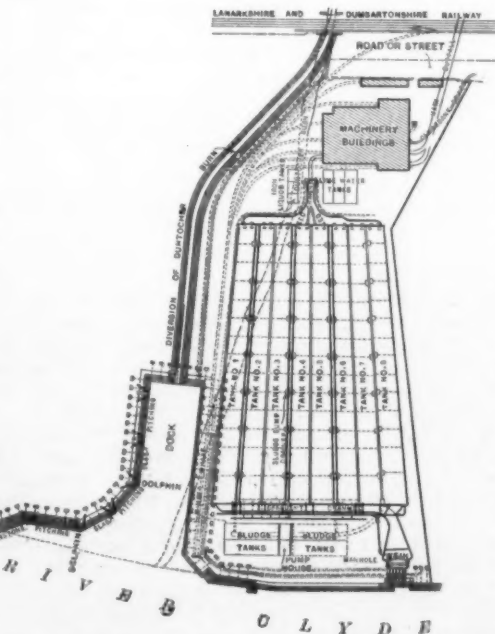
adopted are similar to those at Dalmuir.

Owing to the present distribution of the population on the south side of the city, a much greater proportion of the sewage has to be pumped from this area than from the western section, but as the higher levels of the southern area become populated the disparity will to a large extent disappear.

As the natural conditions for the relief of rainfall are also less favorable than they are on the north bank, a storm-water overflow has been constructed in Kingston District to prevent the surcharge of the Outfall Sewer. The overflow chamber is constructed in St. Andrew's Drive, and the relief sewer is carried under the lines of the Caledonian and the Glasgow and South-western Railways and the sidings in the Corporation Gas Works, to West Street, and thence to the river at Windmillcroft Quay. The other main sewers will discharge excess rainfall through existing street drains, in the manner already described.

The sewers constructed on the south side of the river, like those of the north bank, follow for the greater part of their course the line of public streets and roads. A pumping station is situated at Park Street, Kinning Park, where the low-level sewage of the city is raised 22 feet and forced an additional height of 17 feet up a rising main into the outfall sewer in St. Andrew's Drive. At Shieldhall three centrifugal pumps are installed to deliver into the works the sewage of the Burgh of Govan and the district of South Lanark. The lift is 21 feet.

The works at Shieldhall, designed for the treatment



Plan of Tanks, Outlet Works and Dock at Dalmuir.

which the committee already possessed as to the vastly disproportionate cost of this method of sewage disposal.

The sewage treatment in practice at Dalmuir during the past sixteen years eliminates every trace of suspended matter, and effects 50 per cent of chemical purification, calculated on the albuminoid ammonia basis, and it has to be recorded that the effluent is of a higher quality than any that has been obtained elsewhere by chemical precipitation, either at home or abroad. The daily quantity of sewage disposed of at Dalmuir at the present time is, as we have seen, about 20,000,000 gallons, and it is discharged into a tidal stream of 50-fold volume.

It has not yet been ascertained by any scientific authority what degree of saturation is needed to secure innocuous conditions in the admission of a sewage effluent into flowing water, but it may be safely asserted that there is in this case as near an approach to the complete elimination of every element of objection as could be wished for. Further down the river, at Shieldhall and at Dalmuir, the 96,000,000 gallons of purified sewage will come in contact with something like 3,000,000,000 gallons of tidal water. Natural agencies in the river may with safety be left to effect the final purification and oxidation of the effluent, the more especially as the sewage dealt with on these lower reaches of the river is of a simpler character than that treated at Dalmuir.

The Dalmuir Works, designed in 1891 by the late Mr. G. V. Alsing, were justly regarded at the time of their construction as creditable in the highest degree,

embodying, as they did, the latest results of experience and scientific research. They were then arranged for intermittent precipitation, and worked in connection with coke filters of very limited dimensions, through which the sewage effluent, after passing over a wide surface as an aerating apron, found its way to the river.

More recently the development of experience made it desirable to extend and convert the Dalmarnock Works. The precipitation tanks, as altered by the writer, utilizing the space devoted to aeration, are now enlarged, and worked on the principle of under-surface continuous flow, and the use of the filters has been abandoned, as the process carried on in so insufficient an area, deteriorated rather than improved the effluent. The Sewage Committee, are at present considering the expediency of installing a separate group of filter beds for the betterment of the effluent.

Apart from the Dalmarnock installation, the works authorized under the statutes of 1896, 1898 and 1903, include, as already stated, 30 miles of outfall and intercepting sewers, as well as four separate pumping stations, and two sewage works for the treatment of the collected drainage—one at Dalmuir, the other at Shieldhall.

The works on the Southern Section of the Main Drainage Scheme involved greater trouble in their construction than those on the Northern Section. The invert level of the sewers was found in many places to overlie coal workings of unrecorded date, necessitating an unexpected amount of special construction, in cast-iron segments, instead of ordinary brickwork, and involving the use of pneumatic pressure over a considerable extent of the larger sewers.

Notwithstanding these adverse circumstances, all the sewers are satisfactorily completed.

At the Kinning Park pumping station there are three vertical, triple-compound, surface-condensing, three-crank, direct-acting pumping engines with plunger pumps, each capable of raising 12,320 gallons of sewage water per minute. Steam is supplied by three boilers, with a maximum pressure of 200 pounds per square inch.

Early in the year 1906 the attention of the committee was directed to the various methods of construction which had been, during the past twenty years, in practice on the continent, and more recently in this country,

described, among other protective designations, as reinforced concrete, armored cement, and ferro concrete. Very careful inquiries were made at home and abroad as to the advantage of employing one or other of these methods on the southern works, but it was ultimately found, after very rigid scrutiny and subjecting the matter to the ordeal of public competition, that no financial benefit would accrue to justify any departure from the constructional methods in ordinary use. The contract for the precipitation tanks at Shieldhall was accordingly placed in the hands of a capable and responsible local firm, who carried out the work in the most satisfactory manner.

The general arrangements and details of the Shieldhall Sewage Works are to a large extent a repetition of the methods employed at Dalmuir, and therefore do not require elaborate description. The configuration of the Shieldhall site, differing from that at Dalmuir, necessitated an alteration in the general design. The precipitation tanks occupy a rectangular area, and are disposed in four groups, each containing five tanks, 400 feet in length by 60 feet in width, with a broad effluent channel intersecting the center of the area, and discharging into a basin, from which the effluent passes over a gage weir before reaching the five separate channels that convey it to the river.

The methods for storing and disposing of sludge are the same as those adopted at Dalmuir.

The lime-water tanks are fitted up with a new form of movable mechanical agitator, of a type different from any that has been used elsewhere. The motors and gears are housed at the south end of the tanks.

The major difficulty grappled with at Shieldhall consisted in the water, which percolated the subsoil of gravel and sand in such volumes as almost to baffle the endeavors of the contractor, and made very troublesome the construction of the pump room and other deeper parts of the building. These obstacles, like many others, were surmounted, and the whole works have been in satisfactory operation since May 2nd, 1910.

The difficulties pointed out in the foregoing memorandum, and various other circumstances to which it is not requisite now to allude, have greatly increased the cost of the scheme which exceeds 2,250,000 pounds sterling—

while the maximum assessment, which was originally set down at 6 pence (about 12 cents) per pound, was raised to 7 pence (about 14 cents) by the Corporation Act of 1909. It is not likely, however, that it will be found necessary to impose the full assessment. The present rate is 5½ pence (about 11½ cents).

It is most gratifying to record in this connection that there has been no murmur on the part of the ratepayers, and the hope is indulged that the outcome of this great undertaking will amply justify the confidence and the liberality that the citizens have manifested in its progress and its completion.

A glance at the map appended to this memorandum shows the extent of completed work as contrasted with the work yet to be carried out. The unfinished work is situated within the landward area of Lanark lying north of Glasgow.

The completion of this undertaking will remove from the Clyde the whole of the solid matters of the sewage of Glasgow and the adjacent burghs; therefore, if my native city, Glasgow, can do this, then surely New York with its possibilities should and ought to eclipse us in this respect, and will purify the dissolved ingredients to such an extent as will restore the river to a condition which must exercise a most beneficial influence on the health of the vast population.

Following on this important and costly result, it is the intention of the Town Council to endeavor to arrive at a definite understanding with the upstream and downstream riparian authorities who at the present time pollute the waters of the river without the area of the Glasgow Main Drainage Scheme.

In conclusion, it is worthy of notice that this scheme, which, as already indicated, ranks second throughout the world in point of magnitude, has from its inception been characterized by a singular immunity from fatal accident to workmen or damage to property. That only six lives have been lost in this great and difficult undertaking, whose execution has extended considerably over a decade, is a matter for much gratification. The sum representing damage to property cannot be accurately stated, as the various contractors were bound to meet all claims under this head; suffice it to say that the amount is inconsiderable.

Some Recent Developments in Wood Distillation*

Millions of Cords of Wood Allowed to Go to Rot Are Capable of Yielding Valuable Products

By Thomas W. Pritchard

In taking up the subject of wood distillation, I wish to say in the beginning that, like every one else, I am subject to correction and am anxious to profit by the experience of others. It is only by so doing that we accomplish anything. There have been many improvements in the art of wood distillation since I first began the work, and I know of no industry which, in so short a time, has made such marked strides and which merits so much investigation and criticism.

In 1904 I prepared a paper for the SCIENTIFIC AMERICAN SUPPLEMENT, in which I gave credit for the first commercial work in the distillation of pine wood to James Stanley, who built a small commercial plant in Wilmington, N. C., in 1872. This plant was not a success in the hands of Stanley, and was shortly after taken over by two gentlemen of Danish birth, who were somewhat familiar with similar work which was being carried on in their motherland. One of these men is still living and is actively engaged in the work to-day. I speak of Mr. L. Hanson, who is president of the Spirit-tine Chemical Company of Wilmington, N. C.

It is rather a striking coincidence that the first, and I may say the last plant, has been built in Wilmington, and the last one within a few feet of the former location of James Stanley's plant. This last plant, which is by my process, I shall describe later.

The process, as started by Stanley and carried out by Mr. Hanson, was the old crude method of destructive distillation, which consisted of a series of retorts with condensers attached, set up in brick work with furnaces beneath. The wood was placed in the retorts and the doors closed, fires started in the furnaces and kept up until distillation ceased; the retorts were then allowed to cool and the charge was withdrawn. No attempt was made to control the temperature during distillation, and it was not until years later that the possibilities of varying products, depending on the temperatures, were thought of. By this old method, many different degrees of heat existed in the retort at

the same time, and it was a noticeable fact that the top of the retort was many degrees hotter than the bottom or sides; the loss of heat was very great as it was necessary to heat up the brickwork before distillation started. There was no attempt at first to refine or separate these products; they were pumped into storage tanks and used for the preservation of timber, a creosoting plant having been built nearby, and the creosoting of timber was a part of the company's business.

I do not believe that any one, at this time, even thought of the possibilities of there being turpentine in the products of distillation. I can well recall the time when such a theory would have been hooted at.

I believe that we can safely give credit to the steam process people for the possibilities of the turpentine extraction from fat pine wood. I do not remember its production prior to their activities, and certainly not of good quality and in commercial quantities. This steam process with its variation held out many possibilities to us all at first, but I regret to say that, from my own observation, it has not proved commercially successful, save in a few cases.

Within the last few years still another process has been evolved, which, while not new, still, as applied to the extraction of the products from pine wood, was novel. I refer to the solvent process, for which great things are claimed.

By this process the wood to be treated is first shredded, or hogged, as it is called, and then subjected to the solvent action of naphtha or some other volatile solvent. The solvent combines with the resinous extracts and the resultant liquid is then drawn off and subjected to a fractional distillation. The solvent is recovered and the products are then refined. The solvent process is claimed by many to be the most profitable, and I know that large sums are being spent for the erection of plants using this process. I have always held, however, that there is but one method for the utilization of wood waste in the form of fat light wood; and that is to completely utilize the raw material. In no other industry would we find such a condition as exists where the steam process and the solvent process are in operation.

The taking of a raw material and the extraction of but a proportionately small part of its valuable contents and then throwing the remainder away, is a poor proposition, no matter how you look at it. I believe that every man who has ever turned his attention to this art, has realized from the beginning that the one great essential to be sought was temperature control during all times of the distillation. Many methods have been tried to solve this question, and I feel reasonably sure that it has at last been successfully worked out.

I refer now to the plant I have just completed for the National Wood Distilling Company, of which I am an officer. In describing this plant and the method used, I ask that I be allowed to indicate the weak points in the other processes, as each of these was of assistance to me in developing the new and successful process we have.

Let us take up the old destructive process and see how it bears a rigid analysis: First, for its good points (and I wish to say here that nearly every plant that has been a financial success has been of this type), the destructive process does utilize the raw material and it does produce far greater yields than any other process, the average production from a cord of good wood by the old destructive process being approximately 20 gallons of turpentine, 10 gallons of light oil and 70 gallons of heavy oil, with a residue of 25 bushels of charcoal to the cord. I do not include either alcohol or acetic acid, as their value is slight and varied, and I may say that very few plants distilling resinous woods have found it of advantage to utilize these products.

The first cost of this style of plant is not great in comparison with others, and the expense and difficulty of hogging wood is not a factor.

The weak points in this process are, however, serious defects: First, the lack of temperature control in the retort results in the formation of all sorts of compounds which distill with the turpentine and contaminate it; and this same lack of heat control results in a large percentage of the heavy products being burned in the retort. Any one who has ever operated a plant of this type will readily recall the deposit of carbonized

* Abridged from a paper read before the New York Section of the Society of Chemical Industry, and published in the *Journal of Industrial and Engineering Chemistry*.

matter which has to be cut out of the retort after a short usage. Secondly, the very high temperatures to which the average destructive plant is subject means a comparatively quick wear-out and very heavy upkeep, as well as an enormous waste of fuel. Third, the fire risk in this style of plant is very great, so high in fact, that no insurance company will accept a plant of this type as a risk.

In summing up the good and bad points we may say that the old style destructive process gives us good yields at comparatively low cost, but the products are of inferior quality, the cost of maintenance high and the fire risk great. In addition to this is the factor of time, as it takes very much longer to handle a quantity of wood by this process than by others.

In considering the steam process, we must give it credit for the quality of turpentine produced, and for the essential idea in wood distillation, the temperature control. We must, however, admit that a weak point in this process is the very small proportionate yield of products; secondly, that it does not utilize the raw material to the fullest extent, as a major part of the products of the wood are not extracted, thus necessitating the use of an enormous quantity of raw material to accomplish any great results.

There have been all sorts of claims as to the quantities produced by this process, but after very careful investigation, based on the report of men who are engaged in this line of work, I am forced to the conclusion that from 6 to 15 gallons of turpentine, and from 2 to 4 gallons of pine oil is the minimum and maximum yield for a cord of fat wood, the variations in quantity being due to the difference in quality and treatment.

The expense of production by the steam process is high; the waste of raw material is enormous and without reason. We may, therefore, grant to the steam process an excellent quality of products, with safety of operation so far as fire is concerned, and at the same time we must condemn it for the poor yields, cost of operation and waste of raw material.

Within the last few years still another process has been evolved. I refer to the solvent process, for which great things are claimed. I am inclined to think from what I can learn that the solvent process possesses considerable advantages over the steam process in quantity of production. I also believe that the quality of the turpentine is equally as good, and this process also produces a good yield of rosin. There is still, however, the objectionable feature of a very high fire risk, comparatively high cost of operation and failure to completely utilize the raw material.

The ideal process for the distillation of wood, we may then admit, must possess the following essential features: First, definite control of the temperature during the entire process of distillation; second, a maximum yield of products; third, products must be of good quality; fourth, cost of operation must be comparatively low; and fifth, the fire risk must be minimized as far as possible.

I am going to try to describe a plant which we have recently built in Wilmington, N. C., within a few feet of the original plant of James Stanley.

When I first began work on wood distillation, I realized that temperature control was the one great issue. I tried experiment after experiment to achieve this, and at last discovered that by utilizing the old chemical process of the oil bath, I could get very definite temperature control at comparatively high temperatures. I had great difficulty for a long time in getting an oil which would stand repeated heating without cracking. I finally found, however, a very high fire-test petroleum cylinder stock, which could be heated to 600 or 700 deg. Fahr., without trouble, provided air was excluded. With this fact as a starter I developed our present process, which I will now try to describe.

I can best do this perhaps, by first describing a miniature plant complete, which I had built last year, and in which I ran continuously 96 charges. In the construction of this small plant, I used two pieces of pipe; the inner shell was 8 inches in diameter by 24 inches in length; the outer shell inclosed this, leaving an intermediary space of $\frac{1}{4}$ inch. The ends of this space, of course, were tightly closed. From the inner shell an outlet pipe passed through the space and through the outer shell and connected with an ordinary worm, the condenser. Into the bottom of the outer shell at one end entered a $\frac{1}{2}$ -inch pipe, with the take-off at the bottom at the other end. Connected with this entrance pipe was a small gas hot-water heater, and from the bottom of this hot-water heater, a pipe led to a small rotary pump, and from the pump to a small steel storage tank. The outlet pipe from the bottom of the outer shell opposite end of the inlet pipe led directly to the top of this storage tank, which was inclosed. By means of the small rotary pump, the bath oil contained in the storage tank was forced through the gas hot-water

heater, taking the place that would originally be occupied by the water in the same, and from there went into the intermediary space entering at the bottom, and was circulated around the inner retort, finding its outlet at the bottom of the outer shell farthest away from the inlet, from there passing back to the storage tank through the pump around the retort and so on, thus keeping a continual circulation. Between the inlet pipe and outlet pipe I had a pipe of similar size connected with suitable valves so that the oil could be by-passed and the retort circulation completely cut off. I also had a reserve tank filled with cold oil, which allowed me to introduce cool oil into the circulation at any time. By means of increasing or decreasing the speed of the pump, opening or closing the valves used by passing or introducing cold oil into the circulation, I found it entirely practicable to control the temperature absolutely.

We used in this small retort 20 pounds of wood at a charge, and estimating the weight of a cord of good rich wood at 4,000 pounds, we had no trouble in getting a pretty accurate approximate average of the production by this process. I must confess that the results of this experimental plant were far beyond our most sanguine expectations. We kept a record of every charge, and our average for 50 charges was 36 and a fraction gallons of water white turpentine, 10 gallons of light oil, and 125 gallons of heavy oil.

We found that we had no trouble whatsoever in getting complete and uniform carbonization, so complete, in fact, was the heat distribution by this method that a solid stick of timber 8 inches in diameter and of the length of the inner shell was charred all through.

In operating this model we discovered that by varying the temperatures, we could produce varying products. We also discovered that by drawing off the liquid contents of the retort after the turpentine had been distilled we could produce large quantities of an excellent grade of rosin. In fact, one of the main features of this process is its extreme flexibility.

Our commercial plant, which we have just completed and which is now in daily operation, is an exact duplicate of the model, except for the fact that the space for the bath oil is proportionately about three times as great. The large retort has an outside diameter of 5 feet, with an inner shell of 3 $\frac{1}{4}$ feet, and a length of 28 feet. This gives us 9 inches of oil space between the inner and outer shells.

For heating the oil bath we use a continuous coil of electrically welded pipe, containing 350 linear feet. This pipe is set in a specially constructed furnace so that while not in direct contact with the fire, it yet gets a maximum amount of the heat. The results of this large retort have checked absolutely with the model, and we see no reason why it should not continue to do so indefinitely. I used the same oil bath in the model for 96 continuous charges, and so far as we are able to tell, the bath oil is in exactly the condition to-day as when first put into service. The low cost of this oil and its long service make it an ideal medium for conveying the heat.

In operating this plant, we run the wood into the inner shell of the retort on cars, the doors are closed, and a steam jet is opened with leads into the inner shell. This is done to force out the cold air and so hasten the heating. The oil bath is then circulated from the storage tank by means of a low-pressure pump through the heating coil, and so to the retort where it fills completely the space between the inner and outer shells forming a blanket of hot oil with a uniform temperature, passing out at the bottom of the retort and back to the storage tank. We control the temperature so that the inside heat shall not exceed 450 deg. Fahr., until we have distilled off all the turpentine and pine oil; we then allow the temperature to slowly rise until we have fractionated the light oil, and it is just at this point that destructive distillation begins and fractional distillation ceases. We find that at approximately 480 deg. Fahr. we begin to get the distillates with the distinctive empyreumatic odors. The temperature is held below 525 deg. Fahr. until all the light oil is over and then allowed to increase as fast as possible. We find that at a maximum temperature of 610 deg. Fahr. in the inner shell, we can get complete distillation of all the products, leaving us dry charcoal of excellent quality. At this temperature we find that our bath oil is at a temperature of 650 deg. Fahr., which is as high as we generally carry it, though we have gone as high as 750 deg. Fahr., without trouble. I do not hesitate to say that this process is the most accurate, and the apparatus the most scientific ever evolved for his work, and the results prove it.

At no stage of the process is it not under perfect control and the temperature can be raised or lowered at will. We have found by actual tests that we can hold the temperature of the oil bath at any given degree as long as may be desired. The time consumed in running a charge by this process is comparatively

shorter than by any other; it takes longer than a steam process plant, but when the difference in the production is taken into account, this comparison is in our favor. We actually begin distillation as soon as the wood goes into the retort, as the oil bath is carried to about three hundred and fifty before the cars of wood are run in. After the charge is over, instead of having to wait many hours for the retort to cool, we mechanically assist the cooling by pumping cold oil through the heating chamber.

The fire risk is also a slight danger by this process, and I may say right here that an examiner for one of the leading companies in America has classed our plant as a comparatively safe risk, and is willing to write us at a very fair rate of insurance. In regard to the quantity and quality of the products produced by this method, let me say that both the turpentine and oils are of a very high grade as the samples I have with me show. The analysis of the turpentine shows it to be of remarkable quality. The production is far greater than by any other process with which I am familiar.

This daily record gives an absolutely accurate record of the varying temperatures, both of the oil bath and the inner shell or distilling space. We also get the exact periods and temperatures at which the distillates change in nature. We may, therefore, grant that we have accomplished: first, temperature control; second, the complete utilization of the wood; third, a maximum amount of products.

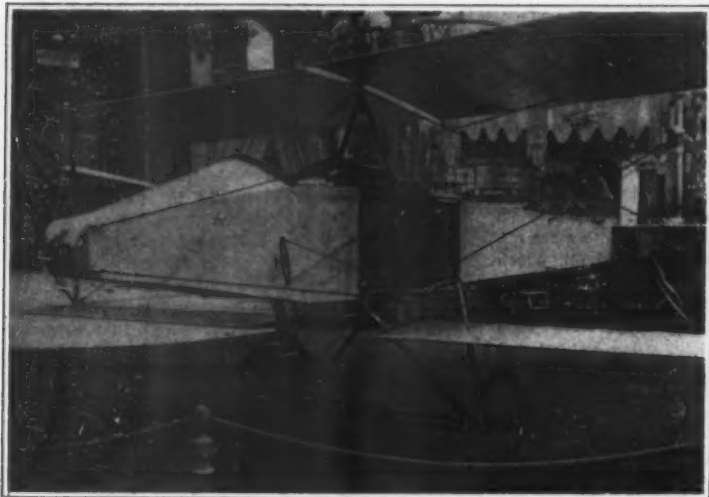
This being granted, let us see what the quality is, and also consider the cost of production. In taking up the question of quality, I wish to say that it is hardly a fair comparison to consider the products made by this process against the old destructive ones, as they seem distinctly different. The turpentine as the following analysis shows is very close to the very best gum turpentine, so close, in fact, that but for one feature it would be indistinguishable; I refer now to the pine oil contents which I may say is the one means of classifying wood turpentine as against gum turpentine. The presence of this product, even in very small quantities, raises the average of the boiling points in fractionation. I believe I am correct when I say that this is the one distinction in even the very best wood turpentine. I am glad to say I am now working on a method of refining which seems to promise an easy and economical method of extracting even the slightest quantity of pine oil from refined turpentine. If this can be accomplished, I do not believe it will be possible to distinguish good wood turpentine from that distilled from the crude gum turpentine.

In comparing the oils produced by this process it is found that the heavy and light oils are very much brighter in color, and have a much milder odor than the ordinary destructive distillates. This is due in part to the fact that they are not burned, and are taken from the retort at their normal distilling temperatures. I have many times seen oils made by the old destructive process so black in color and so high in odor that they were hardly worth marketing, and this was unquestionably caused by exposure to excessive temperatures.

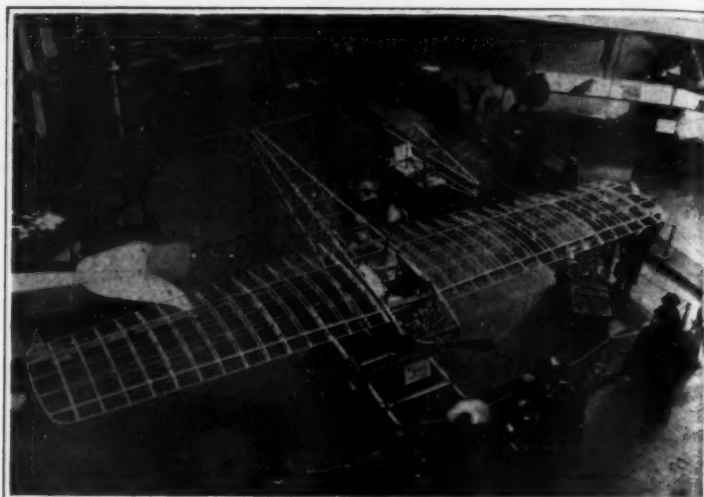
In speaking of the refining of the oils produced from the distillation of pine woods, I would like to say that hardly anything has been done. I have perhaps gone as far along this line as any one, and have made, perhaps, as many as 75 distillates. I believe that this work alone offers a wonderful field for the research chemist, and it has always been a matter of wonder to me that some of our men who have the time and means to take this up, have not done so. I feel sure that no field before us to-day offers greater opportunities for discovery. The subject is so vast in scope that it is with difficulty that I have been able to limit my paper.

I feel that I cannot close without saying just a few words relative to the possibilities of the distillation of pine wood. There are to-day millions of cords of wood lying on the ground rotting, and there is a money value of approximately \$25 in each and every cord of this wood. There are every day thousands of cords of rich pine wood burned at sawmills that have an equal value.

The distillation of pine wood is not an industry which requires large capital. Plants may be built for comparatively small amounts that will pay good dividends. There is an unlimited demand for all the products and at prices which will pay handsomely. Many plants have failed, it is true, but every failure can be safely attributed to lack of knowledge of the industry, lack of capital or a poor process. Many men have gone into the business thinking that they could get fancy prices for the products and have been disappointed. A steady sale at a reasonable profit is all that can be expected. There is, however, a steady demand for all of the distillates now, and this demand is growing daily. The question of timber preservation has become a vital one, and when the fact that the heavy wood oil is even more valuable than dead oil of coal tar for this purpose becomes generally known, there will be an unlimited demand for this product.



The D'Artois Aerotorpedo. The Design of M. Louis Gaudart.



Hanriot Monoplane With Wings Uncovered to Disclose Underlying Features.

Novelties at the Paris Aviation Show—II*

A Fine Exhibition Representative of the Present Development of the Art

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 1926, Page 347, November 30, 1912

In last week's issue we were able to place before our readers a general review of this most important fixture of the aviation year, and commence upon a series of brief articles outlining the main characteristics of the aeroplanes exhibited there. This week we continue the series of descriptions, illustrating them by photographs and sketches. Included in this week's issue is a table giving the principal dimensions and particulars of every machine exhibited at the Salon, and next week we hope to conclude the series of detailed articles.

D'ARTOIS.

The name is a new one, and so are the machines, but the firm that is producing them was one of the earliest to enter the arena of aeroplane construction in France—the Tellier firm to wit. During 1910 the Tellier monoplane came into considerable prominence in the hands of Emile Dubonnet, but since he discontinued flying the firm seems to have altogether dropped constructing, until now that they are re-opening operations with the assistance of MM. Louis Gaudart and Schreck. They are showing two machines, one a rather novel biplane and the other a hydro-biplane, which follows to a certain extent the lines of the Donnet-Lévêque. The first of these machines is of the "torpille" type, that is, it is driven by a propeller arranged at the tail end of the machine. M. Louis Gaudart is responsible for its design, and he will be remembered as the pilot that carried out the initial tests of the Paulhan-Tatin aero-torpille, one of the most notable exhibits at last year's show. Differing from this machine, the d'Artois torpille biplane has a simple fuselage of rectangular section constructed for the best part of wood. Only in the neighborhood of the engine, a 50 horse-power rotary Gnome, is steel used. Excepting in that part, too, the body is covered in with fabric. The landing gear is an extremely simple construction of steel tubing and is of a type that seems to be finding many adherents among French constructors. The main planes are built about a

single tubular spar arranged at the approximate center of pressure. They are united to the fuselage in so simple a manner that it needs but the removal of a bolt or two to dismantle them. Apart from the presence of the propeller, which is driven by a hollow steel shaft of 40 millimeters external and 34 millimeters internal diameter, the tail is of purely conventional design, consisting of a flat stabilizing surface with elevators hinged to its rear edge. As in the Tatin torpille, whipping of the shaft is prevented by a number of ball bearings arranged at equal distances between the motor and the propeller.

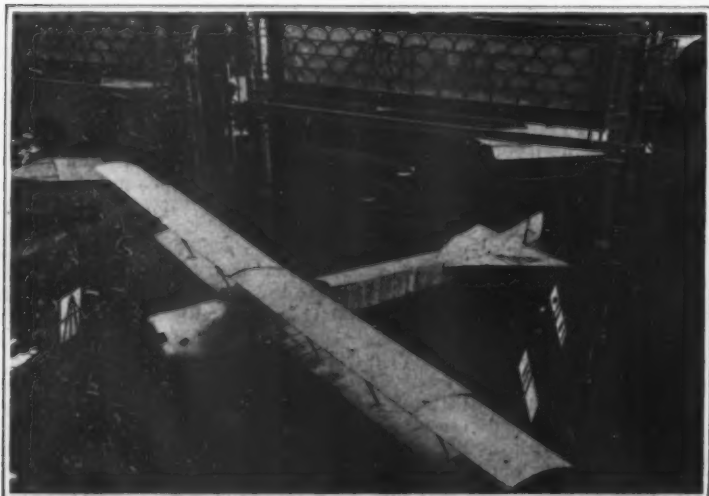
For the hydro-biplane, its central unit of construction is a coque, which serves the double function of fuselage and float. Near the front it is of rectangular section, but aft of the main planes the two top longitudinals merge into one, giving the after portion a triangular section. The pilot sits low down in the body in advance of the planes. Behind him is the motor, a 50 horse-power Gnome, driving, by chain transmission, a four-bladed propeller mounted high up between the planes. Like other hydro-aeroplanes, a starting-handle is fitted. The supporting surfaces are in every respect identical with those of their torpille biplane.

CLEMENT-BAYARD.

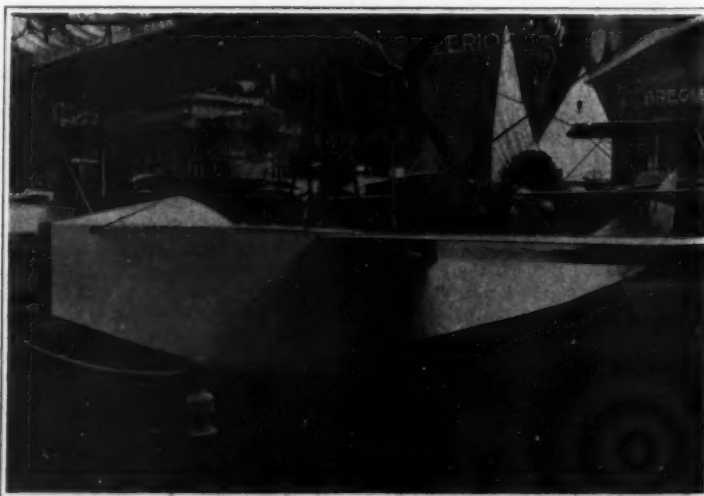
Their monoplane is one of the prettiest jobs in the whole Salon. Hardly the same can be said of the biplane they are exhibiting, for, although good throughout as concerns both design and workmanship, it seems considerably more complicated about the chassis than it need be. The monoplane is a single-seater fitted with 50 horse-power Gnome motor, and betrays traces of R. E. P. influence in its design. Its body, for instance, is almost identical with that of the machine we mention; also, at first sight, is the chassis, but on closer examination it will be seen that it works on a different principle. Its two running wheels are mounted on a common axle, that is strapped down by rubber springs to a horizontal tubular member, which unites the basis of two "V's" extending

downward from the fuselage. One of our sketches shows this point well, and in the same drawing may be seen how the fixed horizontal member and the movable axle are connected as a precaution against an extensive smash occurring should the rubbers break. Altogether, it is the neatest and, we should think, the most efficient chassis this year's Salon has brought forth. On the machine shown the wings are constructed chiefly of wood, but have tubular spars of steel. We were informed, however, that wings with an all-metal skeleton had been made for the monoplane, and, in fact, they would be fitted to the machine before the Show closes. Its tail is a lifting organ, and singularly pretty in outline. It is kept clear of the ground by a neat skid built up of laminations of bent wood.

The large three-seated biplane has a fuselage which only differs from that of the monoplane as regards size. Its tail organs, too, are identical. The main points of difference lie in its landing gear, and in the fact that it has two spreads of wings instead of one. Its chassis is a rather more complicated version of that which was shown on their biplane last year. It consists of two horizontal wooden skids united to the fuselage by a structure of steel tubing. At the rear extremity of each skid is hinged a steel fork in the form of a triangle, which supports a pair of wheels. The shock absorbers are fitted horizontally between the front of the skid and the base of the fork, so that, should there be a shock on landing, the wheels may give in a vertical direction. Behind the two main skids, and attached to the base of the fuselage, is a third skid with wheels, which, in that position, does away with the necessity of fitting a tail skid. The planes of the biplanes are so designed as regards their attachment to the fuselage that they may be dismantled in a minimum of time. A triangular construction of steel tubing surrounds the body in the neighborhood of its center of gravity, and to this structure the planes are assembled. Their cross bracing is rather interesting, and this we



The Zodiac Stand at the Paris Salon.



The Hull of the D'Artois Hydro-aeroplane.

* For information here given we are indebted to *Flight*.



Near View of Nieuport Monocoque.



Clement Bayard Monocoque.

illustrate by means of a sketch, for this system does away with a good deal of strutting and wiring, and materially reduces the head resistance of that part of the machine. Inside the body, room is provided for two passengers sitting side-by-side in advance of the pilot.

M. Robert Grandseigne, who was a year or so ago connected with the English Bristol Company, is now engaged in experiments for the Clement-Bayard firm, with a miniature hydro-monoplane, having more or less the characteristics of the little Santos Dumont-Demoiselle, which this firm used to construct in days gone by. It is to be quite an inexpensive and popular model, priced somewhere in the neighborhood of \$2,000, and fitted with the same type of horizontal opposed two-cylinder motor as those with which the Demoiselles were equipped. Already considerable success has been achieved by this model, and now it only remains to standardize the machine. We may expect its official appearance in about two months' time. Further, we are informed that the Clement-Bayard works have under construction an enormous biplane driven by an engine of 500 horse-power and capable of lifting a load of twelve passengers. As the controls for a machine of this size would be necessarily difficult to operate by manual power alone, power relays, driven by compressed air, are being designed to perform this function at the will of the pilot.

DEPERDUSSIN.

Perhaps no firm can be said to have made more progress than has the Deperdussin company in France. Two years ago they had a small stand in a more or less insignificant position in the gallery, where they showed quite a neat and promising monoplane, which had the peculiarity that it was driven by a six-bladed propeller. By last year they had grown to be one of the chief monoplane manufacturing concerns in France, and this year they come to the Salon with the Gordon-Bennett Cup to their credit. On their stand they exhibit the machine with which Védrine achieved this honor—a monocoque miniature in everything except the engine, which is a colossal rotary Gnome of 140 horse-power. (See the illustration in our last issue.) Naturally, as it is a speed machine—its flying speed is well over 100 miles per hour—everything possible has been done to cut down head resistance to a minimum. Thus the body is of perfect streamline form, and of sufficient girth to totally inclose the pilot, leaving only the upper half of his head exposed. The wings are prac-

tically flat, and their average chord measurement cannot be more than 4 feet, while they do not span more than 22 feet.

Over the front of the rotary motor is applied a semi-spherical dome through which the propeller of an unusually coarse pitch projects. This dome closely follows the bluff lines of the front of the fuselage, but there is sufficient clearance between it and the oil shield to admit air. Scarcely anything simpler than the racing version of the Deperdussin chassis can be imagined. It is constructed of multiple-ply wood bound with canvas. Disk wheels are used.

There is shown on the same stand a very similar model, a single-seater with an 80 horse-power motor. But this has no cowl over the front of the engine.

GOUPY.

Here is shown a hydro-biplane, built to seat three, and driven by an 80 horse-power Gnome engine. In no special point does it differ from the Goupy that was shown last year excepting, of course, in the landing gear which, in the present machine, consists of two pontoon-like floats, constructed by Tellier, supporting the body through steel compression struts.

As a side issue, M. Goupy is making a specialty of a new system of positive control termed the C. A. D. control. For it, it is claimed that, while it may be fitted with the simplicity of the Bowden system, it has the added advantage that it can transmit compression as well as tension.

HANRIOT.

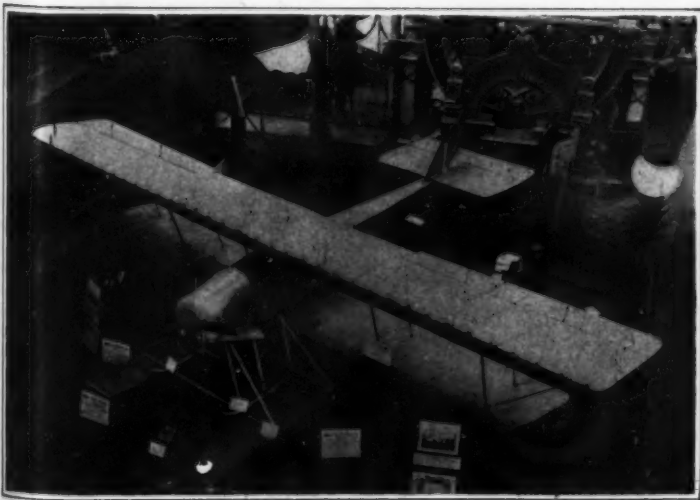
These machines are in general outline a great deal like the Nieuport. The main difference lies in the chassis, which, in the Hanriot, is a particularly neat and robust wheel and skid construction. M. Pagny, who is responsible for its design, gave us a most thorough demonstration of all its fine points. To start with, the workmanship throughout is superb, and that is not only confined to show machines. The machines they turn out in the ordinary course of things are just as finely made.

First of all, the propeller. Most of those who have had anything to do with Gnome-engined monoplanes know what a delicate job it is to remove a propeller that has become stuck on its taper. Unless a special tool is used, a good deal of jarring has to be resorted to, and many good Gnome noses have not been improved by the treatment. Pagny sees this, and obviates it by running a thread at the wider end of the taper, and putting on a

screw ring before the coupling is placed in position. Thus, if it is at all tiresome to remove, just a turn or two of the screw ring will bring it off. Then the motor may be taken out of the machine, carlingues and all, in almost no time. One of our sketches shows this detail well. Each side of the front carlingue is formed as a hinge, the core of which can be removed by knocking out the key that keeps it locked in its place.

The back-plate of the Gnome is treated in the same fashion. There is an interesting fitting, at the cabane on top. All the upper wing cables pass through this fitting, and the whole fitting, cables and all, can be taken clear by unscrewing a nut and lock nut. Thus there is no necessity to disconnect these cables when transporting the machine from place to place, for the wings may be fixed horizontally along the side of the fuselage in special fittings provided for that purpose. The tail is built up of steel tubing acetylene welded. That, too, is made to fold down alongside the fuselage by merely removing a bolt or two. Another of our sketches shows the cockpit and its assortment of cross-country instruments. It also shows the tool box conveniently arranged just behind the pilot's seat. A point of failing about the Hanriot monoplanes that figured in the British Military Trials was that observation was rather difficult. In the 100 horse-power Gnome two-seater shown the passenger's seat is much further forward, and allows of a view almost directly beneath the machine. Another Hanriot monoplane is shown on the Rossel-Peugeot stand. It is an all-metal product and wonderfully made.

As for weight, there is a considerable saving on this machine, for whereas a machine of a similar type in wood weighs, all on, 660 pounds, this model complete turns the scale at only 550 pounds. So that the wings may warp without permanently deforming the wing skeleton, each rib, which only weighs 8½ ounces, is jointed loosely at its four points, the leading edge, the front and rear spars, and the trailing edge. A 50 horse-power Rossel-Peugeot motor is installed in this machine, and, Pagny says, it is giving excellent results. We sometimes wonder why more of this engine has not been heard in the past. It is an excellent job throughout, easily one of the best specimens of rotary engine construction at present on the market, and, by the way, there are quite a number now. It has been in existence something like two years, and yet no one seems to have used it. But perhaps their time is coming now. This, however, scarcely concerns



The Goupy Hydro-biplane Built to Seat Three.



General View of the Salon With Clement Bayard Stand in Foreground.

A Tabular Description of the Aeroplanes at the Fourth Paris Aero Salon.

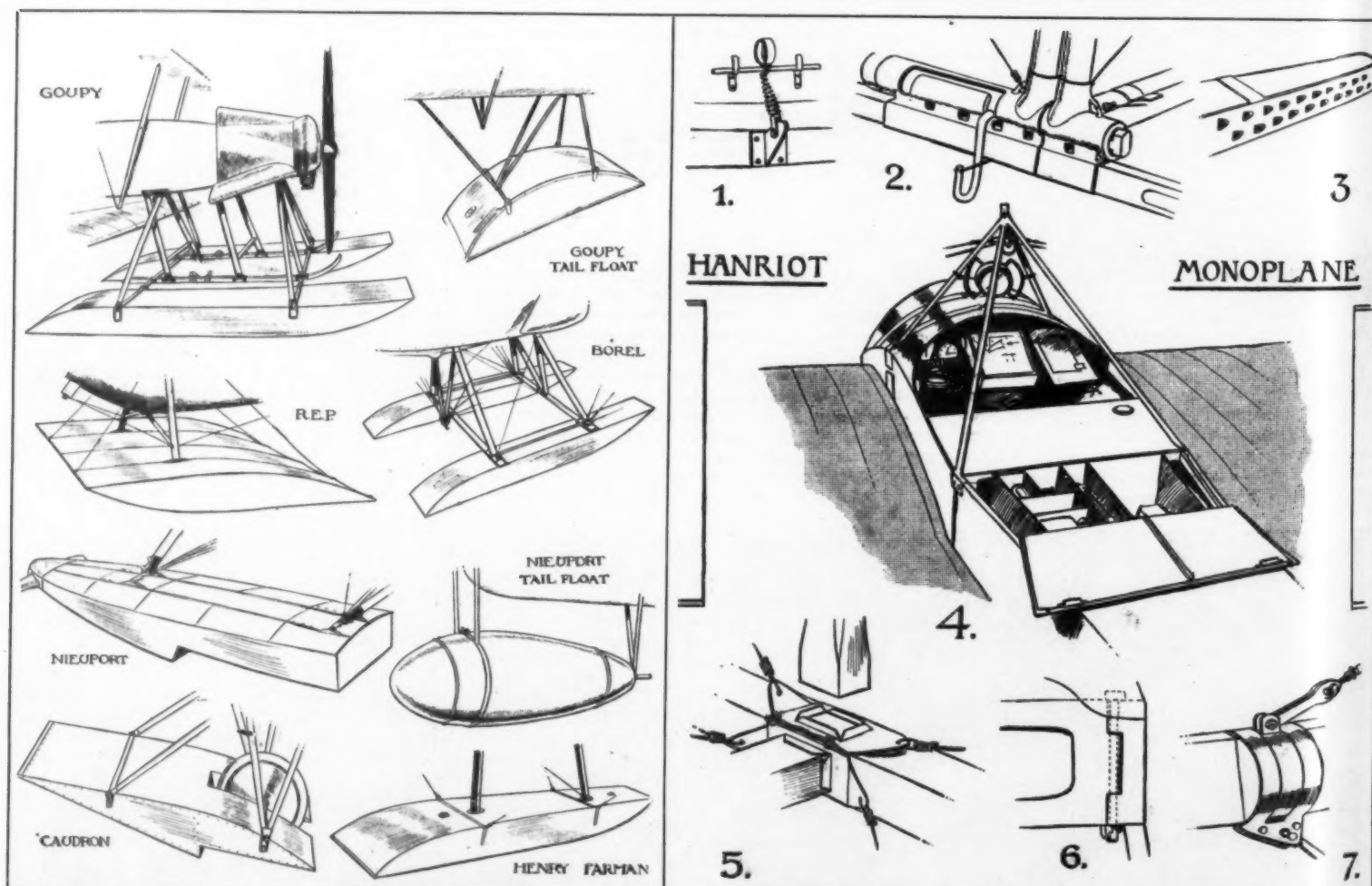
Constructor.	Type.	No. of Seats.	Principal Dimensions.			Weight.		Construction.	Landing Gear.	Controlling.		Type of Body.	Motor.		Propeller.	Price.
			Length.	Span.	Area.	Machine.	Useful Load.			Lateral.	Longitudinal.		h.p. and Type.	No. of Cyls.	Position.	
Astra ...	Hydro-biplane	...	335.44	580	60	...	...	Wood and steel	Floats	Wa.	Rear elevator	Triang. section	100 Renault	12	Front	Integrale ... 1,800
Bertin ...	Monoplane	...	229.34	226	75	...	...	Steel	W. & S.	Ai.	Front elevator	Pent. section	100 Bertin	8	"	" ... 1,400
Besson ...	"	...	222.44	323	60	...	...	Steel	W. & S.	Ai.	Front elevator	Pent. and tri.	70 Gnome	7	Rear	" ... 1,400
Blériot ...	"	...	125.29	162	62	...	...	Wood	W. & S.	Wa.	Rear elevator	Rect. section	50	7	Front	" ... 860
"	Monocoque	...	277.32	215	71	...	...	Wood, steel and cork	W. & S.	"	"	Coque	70	7	"	" ... 1,072
"	"	...	277.32	215	71	...	...	Wood, steel and cork	W. & S.	"	"	Coque	80	7	"	Levasseur ...
Borel ...	Monoplane	...	122.30	152	71	...	...	Wood	"	"	"	Rect. section	50	7	"	" ... 920
"	Monocoque	...	119.26	116	93	...	...	Wood and steel	"	"	"	Coque	80	7	"	" ... 1,040
"	Hydro-monoplane	...	227.37	237	62	...	...	Wood	Floats	"	"	Rect. section	80	7	"	" ... 1,120
Breguet ...	Biplane	...	228.45	388	65	...	...	Steel	Wh. (4)	"	"	Torpedo	80	7	"	" ... 1,500
"	Hydro-monoplane	...	229.42	388	—	...	...	"	Floats	"	Front elevator	Hydroplane	110 Canton-Unné	9	"	Integrale ...
British Breguet ...	Biplane	...	329.47 (44)	400	75	...	...	"	Wheels	"	Rear elevator	Torpedo	110	9	"	" ... 1,850
Bristol ...	Monoplane	...	228.40	216	71	...	...	Wood and steel	W. & S.	"	"	Rect. section	80 Gnome	7	"	Bristol ... 1,400
Caudron ...	"	...	120.28	118	84	...	...	Wood	W. & S.	"	"	Torpedo	50	7	"	Gremont ... 880
"	Hydro-biplane	...	333.45 (31)	376	60	...	...	Steel	FL & Wh.	"	"	"	70	7	"	Integrale ... 1,280
Clement-Bayard	Monoplane	...	125.30	172	78	...	...	Steel	W. & S.	"	"	Pent. and tri.	50	7	"	" ... 960
"	Biplane	...	337.52	538	56	...	...	"	W. and S.	"	"	"	100	14	"	" ... 1,400
d'Artois ...	Biplane torpille	...	123.33 (20)	280	—	...	...	Wood and steel	W. & S.	"	"	Rect. and tri.	50	7	Rear	" ... 800
"	"	...	124.33 (20)	280	—	...	...	"	Coque	"	"	Coque	50	7	"	" ... 800
Deperdussin	Monocoque	...	121.23	97	105	...	...	Wood	W. & S.	"	"	"	140	14	Front	" ... 1,200
Donnet-Leveque	Hydro-biplane	...	228.35	194	59	...	...	"	Coq. & Wh.	"	"	"	50	7	Rear	Levasseur ... 1,200
Doutre	Biplane	...	344.54	700	55	...	...	Wood and steel	W. & S.	Ai.	Front and rear	"	75 Renault	8	"	Integrale ... 1,200
Farman (H.)	Hydro-biplane	...	226.45	344	62	...	...	Wood	W. & S.	"	Front and rear	"	50 Gnome	7	"	" ... 1,280
" (M.)	Biplane	...	239.51	645	59	...	...	Wood	W. & S.	"	Front and rear	"	75 Renault	8	"	" ... 1,280
Goupy	Hydro-biplane	...	226.43	485	75	...	...	Wood and steel	W. & S.	Wa.	Rear elevator	Rect.	50 Gnome	7	Front	" ... 1,400
Hanriot	Monoplane	...	123.29	151	71	...	...	Wood and steel	W. & S.	Wa.	"	"	50	7	"	" ... 1,000
"	" (metallic)	...	123.28	151	71	...	...	Steel	"	"	"	"	100	14	"	" ... 1,920
Morane ...	"	...	121.30	151	70	...	...	Wood and steel	W. & S.	"	"	"	50 Rosell Peugeot	7	"	" ... 1,000
"	"	...	224.37	194	70	...	...	"	W. & S.	"	"	"	50 Gnome	7	"	" ...
"	"	...	224.36	226	70	...	...	"	W. & S.	"	"	"	50 Gnome	7	"	" ...
Moreau	"	...	231.39	258	63	...	...	"	W. & S.	Ai.	Automatic	"	75 Renault	8	"	" ... 1,280
Nieuport	" (racer)	...	121.23	140	90	...	...	"	W. & S.	Wa.	Rear elevator	Rect.	50	7	"	" ... 1,000
"	"	...	123.28	155	66	...	...	"	W. & S.	"	"	"	28 Nieuport	2	"	Regy ... 720
"	Hydro-monoplane	...	329.40	242	72	...	...	"	W. & S.	"	"	"	80 Gnome	14	"	Integrale ... 1,200
R.E.P.	Monoplane	...	225.39	215	68	...	...	Steel	Float (1)	"	"	Pent. and tri.	100	7	"	" ...
"	"	...	226.36	237	75	...	...	"	W. & S.	"	"	"	90 R.E.P.	7	"	" ...
Sanchez Besa	Biplane	...	313.54	538	60	...	...	Wood and steel	W. & S.	Ai.	"	Rect.	70 Renault	8	Rear	" ... 920
Savary	"	...	316.44 (47)	53	1430	...	...	"	W. & S.	"	"	"	75	8	Front	" ...
Sloan	"	...	329.43 (29)	473	65	...	...	Wood	W. & S.	"	"	"	120 Laviator	6	"	" ... 1,280
Sommer	Monoplane	...	122.28	172	68	...	...	Wood and steel	W. & S.	Wa.	"	"	50 Gnome	7	"	" ... 1,280
"	Biplane	...	241.52 (34)	580	55	...	...	"	W. & S.	Ai.	Front and rear	"	70 Renault	8	Rear	Rapid ... 880
Tubavion	Monoplane	...	217.33	215	65	...	...	Steel	"	Wa.	Rear elevator	"	70 Gnome	7	"	Integrale ... 1,280
Vinet	"	...	121.28	162	60	...	...	Wood	"	"	"	Rect.	50	7	Front	Normale ... 880
Zodiac	Biplane	...	237.49 (36)	345	60	...	...	"	"	Ai.	"	"	50	7	"	Integrale ... 1,120

W. & S. = wheels and skids.

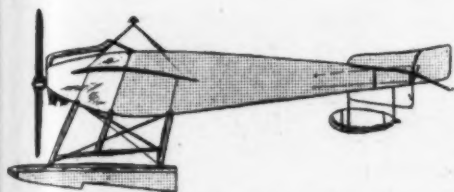
Fl. & Wh. = floats and wheels.

Wa. = warping.

Ai. = Ailerons



Details of the Hanriot Monoplane.—1. The fitting by which the aluminium side-plates are clipped to the fuselage. 2. An ingenious fitting by which the fuselage may be divided so that it can fold in two. To dismantle or re-erect the fuselage takes no longer than the time required to operate the bolt of a rifle. 3. Showing how the rear part of the main skids are shod with steel and punched out to act as a brake. 4. The pilot's cockpit, showing his instruments, the fuel-tank, and his chest of spare parts and fuel. 5. The cross-bracing socket, stamped from sheet steel. 6. One of the four bolts which, being removed, allow the engine, together with its carlingues, to come clear of the machine. 7. The method of attaching the wing wires to the main spars.



The 100 Horse-power Nieuport Hydro-monoplane.

the Hanriot monoplane. All praise to them!

NIEUPORT.

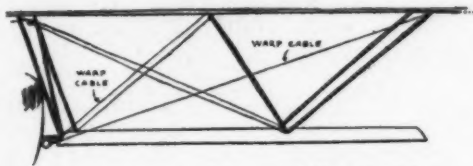
Four machines are shown on this stand—a standard 50 horse-power Nieuport monoplane of the school type, a standard 70 horse-power two-seater, a new racing model, and a 100 horse-power. "Hydravion," similar in every respect to the one that hangs suspended from the roof above the exhibit of the French Minister of War. No special description of the first two models is necessary. They are quite standard; and, for that matter, very little need be said of the last two, for in the case of the racing model the machine is simply a smaller edition of the standard machine with changes in the chassis, and, for the Hydravion, it is but the ordinary 100 horse-power three-seater model with a float chassis instead of a wheeled one.

Let us first deal with the racing model. To attain high speed the designer has not resorted to high engine power. He has kept to the 50 horse-power Gnome, and to increase the speed has aimed at still further increasing the efficiency of the machine by cutting down head resistance.

This is chiefly noticeable in the landing gear, which, as a light construction having little head resistance, is perhaps good. But, as a landing gear, pure and simple, we doubt if anything more treacherous has ever been designed. As long as it is used only on smooth ground, it may stand up to its work all right—that is, if it were in the hands of a skilful pilot. What would happen over rough ground we dread to imagine. The chassis is all of steel, and there are only two laminations in the transverse spring.

There being no horizontal skid it is impossible to arrange the warping as heretofore. On this machine it is operated by bell cranks just below the fuselage, worked by the feet as usual. To cut down some of the head resistance of the Gnome engine, a dome is fitted over the front, a quarter segment of it being cut away to admit sufficient air for cooling. The wings only span 23 feet and they have noticeably less curvature and incidence than previous models. They are each stayed on the underside by four cables—two to each spar.

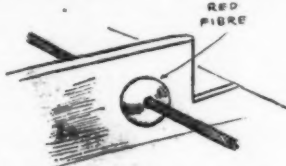
As regards the Hydravion, it has three floats. Two-stepped floats, supporting the body through a construction of steel tubing form the main landing organs, and a



Bracing of the Planes of Clement-Bayard Biplane.

miniature egg-shaped float supports the tail. For the construction of the main floats cypress wood is employed. A peculiarity about these are the small fin-like projections that extend laterally from the front ends of each float. They are so designed for a double purpose—to prevent the floats burying in a heavy sea, and to protect the propeller from spray. The propeller, by the way, is further armored at the tips. A change has been made in the building of the fuselage to strengthen it to withstand the heavier strains that landing in the water calls upon it to bear. In this machine, the vertical struts in the body are of steel tubing, although the longitudinals and other portions of the body are still made of wood.

Two passengers can be accommodated in a wide seat immediately behind the pilot. He, the pilot, has before him, in addition to his controls and instruments, a start-



The Neat Control-Wire Guide on the Nieuport Monoplane.

ing-handle, by which he can put the motor in motion without exterior help.

SAVARY.

Since last year this firm do not seem to have changed their methods at all, and they remain almost the only firm of biplane manufacturers that have not been influenced by the monoplane trend in biplane design. Their present machine is fitted with a 75 horse-power Renault which is mounted in a rather neater manner than the

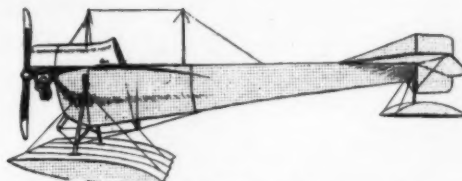


Two Details of the Clement-Bayard. On the Left the Rear Skid; on the Right the System of Shock Absorbers Employed in the Chassis.

engine on last year's machine. This point we illustrate. They are also showing, in a semi-finished state, a hydro-monoplane, the chief peculiarities of which are that it has a metal torpedo body and that the wings are stayed from the floats by an haubannage of steel tubing.

R. E. P.

Among the hydro-monoplanes there is little doubt but that the R. E. P. two-seater is the favorite, partly because of its attractive appearance, but mainly because of the excellence that is shown in its construction and design



The 50 Horse-power R.E.P. Hydro-monoplane.

throughout. When resting on the water its main weight is sustained by one large Fabre float 10 feet wide, and measuring 8 feet from front to back. A single float seems to harmonize with the general appearance of a monoplane a great deal better than a pair of pontoon-like floats such as most of the other constructors fit. In assembling this float to the fuselage the same system of flexible suspension is made use of that is employed on the standard land machine. It is the only hydro-aeroplane shown at the Salon in which provision is made for the absorption of any shock that may be caused by landing suddenly upon the water. In addition to this, the construction of the Fabre float materially assists in deadening the shock. This, in fact, is M. Henri Fabre's chief claim for his floats, that they are flexible and give to a certain extent under the hammering influence of the waves. The bottom of his floats are covered with three-ply wood 5 millimeters in thickness. There are no transverse struts to support this, except one at the leading edge, for, were they fitted, it would render the float too solid for M. Fabre's liking. The top of the float is covered in with strong fabric, tested to withstand a tension of 7,000 kilogrammes per square meter.

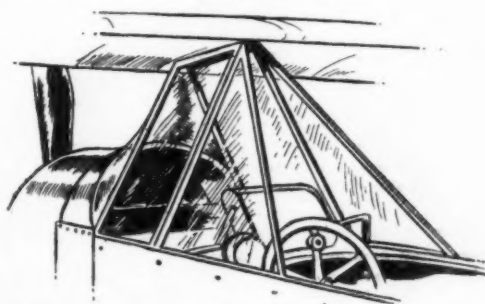
As for the remainder of the machine, it is purely standard in every respect, and remains one of the most notable examples of monoplane construction existing. It is interesting to mention that the machine shown on this stand is the identical one with which Molla carried off the first speed prize at the Tamise hydro-aeroplane meeting in Belgium some time since. It is equipped with an 80 horse-power Gnome engine.

ZODIAC.

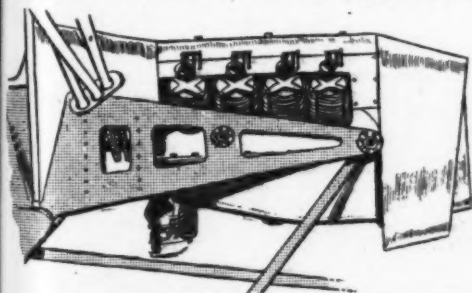
The Zodiac biplane has made no visible change at all since last year, except for the addition of a transparent shield above the pilot's and passengers' seat. Our sketches show this point, and also give a general idea of the machine.

It must be a wonderfully efficient biplane, for it must be no mean weight, and it does all sorts of passenger-carrying work with a 50 horse-power Gnome engine. The high aspect ratio of its planes must be responsible for this, as well as the saving in head resistance of a neat and clean chassis.

(To be continued.)



The Pilot's Seat of the Zodiac Biplane, Covered in With Non-inflammable Celluloid to Protect the Occupant.



Showing the Method of Mounting the 75 Horse-power Renault Motor on the Savary Biplane.

Enzymes and Inhibitors

By A. Hardens, D.Sc., F.R.S.

It has become apparent, as bio-chemical research has progressed, that one of the devices employed by the living cell to regulate enzyme action, is the simultaneous production of an inhibiting substance which either totally prevents the action of the enzyme or greatly modifies its intensity. Thus to take only a single example, in the yeast cell the powerful digestive enzyme—*invertase*—is accompanied by an anti-protease, in the presence of which the action of the enzyme is largely diminished. (Buchner and Haehn.)

These two antagonistic agents pass into the juice expressed from ground yeast and can be separated by boiling the liquid. The anti-protease being thermostable is unaffected, while the tryptase loses its activity.

A still more interesting case, in which the enzyme and inhibitor occur actually combined together has been revealed by the researches of Dr. S. Hedlin on Rennet, the results of which have recently appeared in a series of papers in Hoppe-Seyler's *Zeitschrift*.

Rennet is usually prepared by extracting the mucous membrane of the calf's stomach with dilute acid, and is then obtained in the form of a highly active solution. When, however, the extraction is made with cold water,

the solution is found to possess only a slight degree of activity. If it be subsequently treated with dilute acid, however, it acquires a power of clotting milk equal to that of the extract made originally with acid. This phenomenon has been explained on the ground that the water extract contains an inactive mother-substance of the enzyme, or zymogen, which is converted by the action of the acid into the active enzyme. Hedlin's experiments have, however, revealed the remarkable fact that this so-called zymogen is in reality a compound of the enzyme and an inhibitor, and that by suitable treatment either the active enzyme or the inhibiting substance can be obtained from it. It all appears simple enough, once we have the key to the situation.

By treatment with dilute acid the active enzyme is liberated and the inhibitor destroyed, while with dilute alkali (ammonia) the enzyme is rendered inactive and the inhibiting substance left free. When solutions containing the two antagonistic substances are mixed, combination again occurs, and when suitable proportions are used the resulting liquid has only a very slight clotting power.

A comparative study of the rennet enzymes of different animals has brought to light a still greater complication. Inhibiting substances can be also obtained from the extract prepared by water alone from the

stomach membrane of the pig, the guinea pig, and the pike precisely in the same way as from the calf. Each of these inhibitors when added in suitable amount to the rennet prepared from the same animal completely removes its power of clotting milk. When, however, the inhibitor from one animal is added to the active rennet from another animal, the inhibitor from the guinea pig for example to calf's rennet, or the inhibitor from the calf to guinea-pig's rennet, no inhibition whatever occurs—the relation of inhibitor to rennet is strictly specific. It follows from this that both the enzyme and its inhibitor are different for each animal, a fact of great interest and importance. In spite of this difference, however, all these enzymes are equally capable of clotting cow's milk. It appears, therefore, that identity of action upon a given substance is not sufficient ground for the conclusion that two enzymes are identical. In most cases, however, this evidence is all that is available. The invertase from each of the different yeasts, bacteria, molds, etc., which contain it, is usually regarded as but one enzyme because it exerts the characteristic effect on cane sugar. In the light of Hedlin's experiments this can no longer be assumed, the probability would indeed rather appear to lie in the direction that each of these is a distinct substance. —The Chemical World.



The Excavations for the New Grand Central Station. View Looking South from Forty-fourth Street and Vanderbilt Avenue, May 23d, 1911.

A Gateway to the Heart of New York

The New Grand Central Station and its Relation to New York Traffic

Through articles appearing in a previous and in the current issue of the SCIENTIFIC AMERICAN our readers have been rendered familiar with the main features of that wonderful feat of engineering and architecture, the new Grand Central Station which is nearing completion in the heart of our Eastern capital. We shall here add some brief notes of a supplementary character to the information already given.

Perhaps the readiest measure of the immensity of the enterprises which center around the great railway terminals of our metropolis is obtained when we reduce all to that universal common denominator, the dollar. It must be remembered that the Grand Central Station forms part of a greater system of railway terminals which

receive the various lines converging upon the principal port of our East coast. Says the *Wall Street Journal*:

"Including expenditures already arranged for, railroad passenger terminals in and around New York city, and traction lines within the city, will represent an investment of over \$1,100,000,000.

"Division of this huge investment may be made about as follows:

Traction lines in Manhattan and Brooklyn..... \$784,000,000
R. R. facilities devoted to passenger business..... 397,000,000

Total..... \$1,181,000,000

"The investment in traction lines constitutes about 65 per cent of the total.

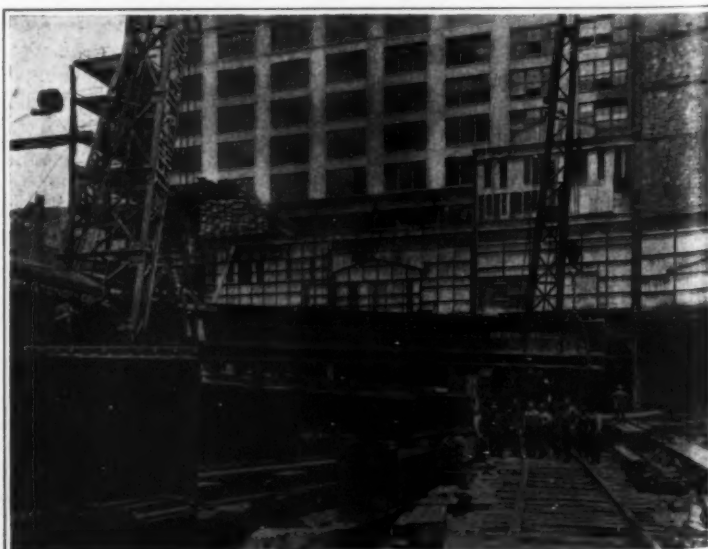
"Of the \$784,000,000 in traction lines, \$497,000,000 has already been expended and \$287,000,000 additional outlay has been arranged for in connection with the new subways and elevated ex-

tensions. How these figures are arrived at is shown in the following tables:

"Money already invested in Manhattan:	
City money in present subway system.....	\$52,000,000
Interboro money in present subway.....	48,000,000
Book cost of Manhattan elevated lines.....	109,000,000
Book cost of surface lines (inc. Third Avenue).....	134,000,000—\$343,000,000
"Money to be invested in Manhattan:	
City money going into new Interboro subway.....	\$60,000,000
Interboro money going into new subways.....	\$77,000,000
Interboro money going into elevated additions.....	25,000,000—162,000,000
Grand total for Manhattan.....	505,000,000



Much Ingenuity Was Necessary in Maintaining the Overhead Footways During Construction.



Hoisting Into Place Some of the Massive Steel Work of the Express-level Construction.

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"Money already invested in Brooklyn:
Book cost of B. R. T. properties, surface
and elevated.....\$126,000,000
City money in Fourth Avenue and loop
lines now nearing completion..... 28,000,000— 154,000,000
"Money to be invested in Brooklyn:
City money going into new B. R. T.
subways.....\$65,000,000
B. R. T. money going into new subways,
elevated line extension and equip-
ment.....\$60,000,000— 125,000,000
Grand total for Brooklyn..... 279,000,000
Total for both districts..... 784,000,000
*Includes \$21,000,000 for new equipment.
†Includes \$26,000,000 for new equipment.

"Not more than five years, and probably not more than four, will elapse before this entire \$784,000,000 will have been invested in New York and Brooklyn transit facilities. In the meantime expenditures for various odds and ends will unquestionably bring this figure to above \$825,000,000.

"To-day the Pennsylvania Railroad Company, quite the largest of the country's transportation corporations, carries its plant and equipment at a book value of \$403,000,000. Including \$246,700,000 securities of affiliated corporations owned, \$61,700,000 marketable securities and other minor investments, Pennsylvania's property account totals \$727,700,000, or almost \$100,000,000 less than the combined accounts of New York city traction corporations will be when the \$825,000,000 traction expenditures are completed.

of the city and it would surprise nobody if Brooklyn's population at the next census exceeds that of Manhattan. Even with all the provision made for Brooklyn in present plans, it is probable that new needs will spring up within five or six years in that borough requiring large capital outlay.

"It would be folly to attempt to predict what the investment in New York traction lines will amount to five or six years from now, but it is obvious from the foregoing figures that the time is not far distant when \$900,000,000 will represent the property devoted to such purpose."

A very interesting comparison is made with regard to the land purchases and values involved in the building of the two great terminals of our metropolis, the Grand Central Station on the one hand, and the Pennsylvania Station at Thirty-third Street on the other:

"That Pennsylvania had just as good an opportunity to enter upon a real estate development in connection with its terminal as New York Central has at the Grand Central is an impression that has become quite common. But an understanding of the facts and features of both propositions would seem to lead to a different conclusion.

"Much of New York Central's terminal land at Forty-second Street was acquired more than half a century ago when real estate prices were infinitesimal compared with quotations to-day. The company owns 47 acres which cost it, all told, \$22,000,000, or only \$10.75 per square foot. Per acre, the cost was \$468,085. Now if

be covered with rentable buildings, leaving 24 acres with nothing above the tracks but public streets that it must provide by means of viaducts.

"The New York Central is contributing to the investment in New York passenger terminals to the extent of \$100,000,000, or about \$15,000,000 less than the amount invested by the Pennsylvania. This represents simply the expenditure on the railroad plant alone and is not intended to include any of the money to be spent for the real estate development. Of this \$100,000,000 \$49,000,000 in round numbers is going into Grand Central Terminal improvements, including stations and office buildings, track structures and viaducts for the streets. The value of the real estate being used for the terminal, or rather the actual capital investment represented in such real estate, is approximately \$22,000,000. Electrification from the terminal to Croton on the Hudson division and to White Plains on the Harlem division has cost about \$16,000,000, while four-tracking, station improvements and grade eliminations within the electric zone call for \$13,000,000. This is all money spent in connection with strictly railroad improvement at the terminal.

"The area of the Grand Central terminal is 47 acres, of which 23 acres will eventually be covered with rentable buildings. It will be some years, of course, before all of the space is fully utilized; and until plans for the development take more definite shape it cannot be determined just what the income possibilities are. As is well known, however, the New York Central directors expect to be able to derive sufficient revenue from their proposed realty plan to offset charges on the entire \$100,000,000 going to reconstruct



Erecting the Girders of the Roof Over the Express Concourse.
GENERAL VIEW OF THE STEEL FRAMING OF THE TERMINAL BUILDING.

"Of course the investment in Pennsylvania is bound to increase during the next three or four years, and by the time \$825,000,000 has been invested in New York tractions Pennsylvania's property and security account will be considerably larger than it is to-day. Pennsylvania's big work, however, is now for the most part behind it, while New York's transit needs will require some millions more even after the work already arranged for is completed.

"Present plans, for instance, make no provision for the needs of the Borough of Richmond on Staten Island. Were it not for the isolation of Staten Island and the consequent difficulties in getting to Manhattan, that locality would be one of the most attractive residential sections of New York city. As it is, the entire Borough of Richmond contains a population of but 89,573 or 1,664 persons for each of its 53.82 square miles. How thinly populated that part of the city is may be understood from the following:

	Area	Pop. Per
	Sq. Miles	Sq. Mile
Manhattan.....	2,389,204	21.93
Brooklyn.....	1,710,861	77.62
Queens.....	310,523	129.50
Richmond.....	89,573	53.82
Bronx.....	483,224	40.73

"That Richmond may share in the city's growth, a tunnel will be extended from Fort Hamilton, the present terminus of the Brooklyn Fourth Avenue subway, which is now nearing completion, under the Narrows, the gateway of New York harbor, to a point on Staten Island. Probably \$25,000,000 or \$30,000,000 will be spent on that account. Then there will be various extensions into Queens, where, as will be seen in the table, there is great room for growth. Brooklyn is growing more rapidly than any other section

New York Central were to buy this same land to-day, it certainly could not get it for \$22,000,000, or \$100,000,000, and the doubt is well founded that \$122,000,000 would suffice.

"So the statement is likely to go unchallenged that New York Central had over \$100,000,000 worth of real estate which cost it \$22,000,000 when it launched its terminal-realty enterprise.

"The Pennsylvania Railroad on the other hand did not own a foot of land where its terminal rests, and although it purchased real estate in secret, 28 acres of it, it had to pay the land speculators who guessed right a little profit. So in 1902 the management wrote off \$5,000,000, which it considered exorbitant or excess price paid, from the cost of the land purchased.

"Thus, instead of starting its terminal on land costing a minor fraction of its current value, Pennsylvania not only paid modern prices, but gave up a premium created by its desire for and need of other people's property. And no more than anybody else could Pennsylvania carry out a real estate development and wind up with a profit, when inflated prices had to be paid for the basic requisite, the land. Money at 4½ per cent or 5 per cent, does mighty well to pay its board in New York real estate, and it is only in such rare instances as the Hudson & Manhattan terminal buildings that the return on the investment equals over 7 per cent or even 6 per cent. For its purpose, Pennsylvania could not get along with less than 28 acres. To cover this area, or a substantial part of it with buildings, would have necessitated the purchase of a good deal more. New York Central with its 47 acres has all the room needed for its purpose—room that is cheap, so far as the cost to itself goes. And not the least interesting point of the whole thing is that when Central's plans are completed, it will have more uncovered terminal than the Pennsylvania. Of the 47 acres, 23 will

the terminal property.

"To understand how the company will be able to do this it is only necessary to obtain an idea as to realty values attaching to the property. Although the Central paid but \$22,000,000 in all for the land, it is worth probably five times as much. Per square foot cost to the company was but \$10.75 for the 47 acres; pro-rated over the 23 acres to be built upon, it was but \$22.

"It is unquestionably conservative to place the value to-day at \$100 per square foot. The corner of the property at Vanderbilt Avenue and Forty-second Street, for instance, is being held to be leased on a value basis of \$200 per square foot. At Madison Avenue and Forty-eighth Street, more than a block away from any part of the terminal and a much less desirable spot, a plot 27 by 100 feet was recently transferred at \$210,000 or \$77 per square foot; and another near it, 45 by 100, for \$300,000, almost \$70 per square foot. The Manhattan Hotel site at Madison Avenue and Forty-second Street is estimated by real estate men to be worth more than \$200 per square foot and the Hotel Belmont, directly opposite the terminal at Park Avenue and Forty-second Street, would be considered cheap at \$200 per foot. Around on the side streets leading away from the western side of the terminal, property brings at least \$50 per foot.

"With 23 acres of rentable ground, the company has just about 1,000,000 square feet which, at an average of \$100 per foot, is worth \$100,000,000. It is only fair to state that this is not the company's valuation of their property, but is arrived at after obtaining the consensus of expert real estate opinion. As a matter of fact, the Central people deem its value much greater.

"Placing the ground value at \$100,000,000, the entire area may be leased at a rental of 5 per cent net, or for \$5,000,000 per annum

over and above taxes. The plan, it is understood, is to have the lessees construct the buildings, the railroad company, through a realty subsidiary, probably, loaning the lessees 7 per cent of cost. Lessees in addition to the 5 per cent ground rent will pay 2 per cent per annum into a sinking fund which, at the end of from 21 to 28 years, would pay off the 70 per cent loan. Then a new lease will be made on the basis of ground rental alone.

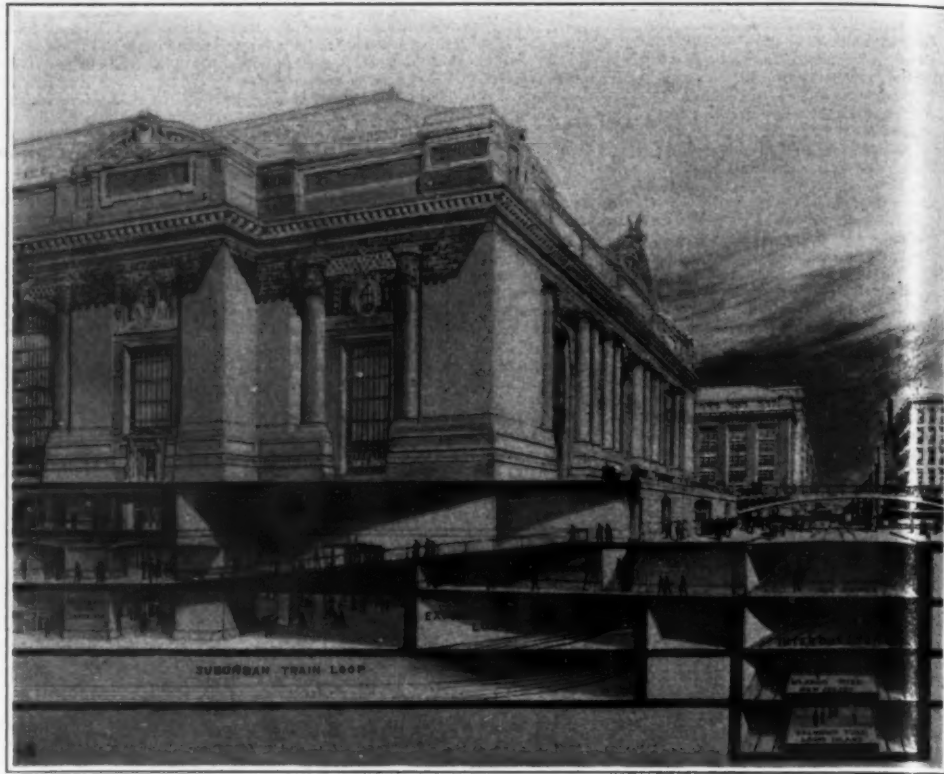
In the history of railroad building there is nothing to compare with the work at the Grand Central. It is a comparatively easy matter to dig a hole, lay tracks and put up a building, but to rebuild a station under traffic, change the entire plant so that not a vestige of the old remained, keep 800 trains running and handle from 75,000 to 100,000 passengers a day, was a proposition alive with engineering and operating problems. To do this, the first thing required was more room.

The purchases of land made, abutting Lexington, Park and Madison avenues, increased the area from twenty-three acres in the old terminal to seventy-nine acres in the new, including both levels of tracks. As each new track or group of tracks was finished a corresponding number of old ones was abandoned, and traffic went on without interruption. How well this problem of building a terminal and operating trains at the same time has been worked out is illustrated by the travel over Labor Day this year. During the eight days from August 30th to September 6th, 1912, the number of people in and out of the terminal totaled 944,000. There were 4,826 trains handled during this same period with an average delay of but twenty-one seconds per train, which is as nearly perfect a record as the most skillful operation can effect.

We shall not here enter into a general description of the main building, as this has already been given elsewhere. But one or two points deserve special mention. One of the unique features of the building, that means a great deal to the city of New York, because it opens up a new north and south thoroughfare, is the overhead street. This approaches the building centrally at Forty-second Street, being carried over this as a viaduct. It then winds around either side of the Grand Central building as a broad terraced roadway raised above the main street level. It is by this street that Park Avenue passes around the station and continues north from Forty-fifth Street. The establishment of this new avenue will tend greatly to relieve the congestion on Fifth Avenue. From the overhead street there will be a cab entrance to the east side of the station, enabling vehicles coming up Park Avenue from south of Forty-second Street to drive directly into the station, and after discharging their passengers leave the station on the Vanderbilt Avenue side.

The outbound concourse, the principal feature of the main building, is a magnificent room 275 feet long, 120 feet wide and 125 feet high. Only when standing under its vaulted ceiling can its impressive proportions be appreciated, and even then one hardly realizes that it could accommodate fifteen regiments of infantry. It is finished in Botticino marble and buff-tinted stone, which, under the light that falls softly through six great dome-shaped windows, gives a most pleasing and cheery effect, nothing austere or cold.

When we remember that the track layout comprises over thirty-three miles, the upper level having forty-two tracks, twenty-nine of which are adjacent to platforms, and the lower level having twenty-five tracks, seventeen of which are adjacent to platforms, we can form some



View Showing the Suburban Concourse, the Express and Suburban Loops and the Interboro, Hudson, and Belmont Subway Tunnels.

idea of the elaborate system of switches and signals required to regulate the traffic in this highly congested center. Indeed, without the aid of electricity, such regulation would be entirely impossible. The working of switches and signals is effected entirely by electricity, one motor being provided at each signal and at each switch. There are in all some 230 switch-boxes in the yards, representing an outlay of about \$260 apiece. A highly perfected mechanical interlocking device absolutely precludes any possibility of conflicting signal and switch setting, thus insuring the safety of the passengers. There is also a separate electric-locking device which prevents a switch being set in such manner as to split a train, or to send one on to a track occupied by other cars. This mechanism is operated by the short-circuiting of an alternating current track-circuit by the axles of cars standing upon a given rail section.

The main signal tower is located at Forty-ninth Street. This tower is a four-story building below the street level, and houses the interlocking machines by which the switches and signals are operated. The machine for the suburban level is the largest ever constructed, and has four hundred levers, each of which operates a switch or signal. On the floor above is a machine with three hundred and sixty-two levers, operating the switches and

signals on the express level. To each forty levers a man is assigned who works under the instruction of a train director, who decides upon the track that each train is to be placed. The movement of the trains is indicated by little electric lights on a chart which is a fac-simile of the track layout of the yards. As the trains pass over the switches the lights on the chart are extinguished and not relighted until the train has passed over the switch onto the next one. The switches and signals are interlocked so that no error on the part of the operator can set a signal one way and a switch the other. Both must agree and the safety of the train is thereby assured. The directors in these two towers control the movement of eight hundred trains in and out of the terminal each day. Another entirely new feature is the system of advising the gatemen on the concourse when to open the gates and admit passengers to the trains. An electric lamp is sunk in the hand-rail in front of each gate and when the train is ready to receive passengers the conductor presses a button, illuminating this lamp, thereby notifying the gateman that all is ready. At the moment the train is due to leave the gateman will close the gate and press a button located on the same hand-rail, which will illuminate a lamp on the platform near where the conductor will stand, thereby notifying him that the gate is closed and he may proceed.

Some Experiments in Carbon Printing Without Transfer

By Frank E. Huson

A DISADVANTAGE of the process for producing prints in monochrome which I have experimented with, and of which details follow, is that, with an ordinary negative, we get a single transfer effect, i. e., reversal as regards right and left; but by using the process adopted in general for screen-plate processes, it becomes an easy matter to secure a new negative where no reversal is permissible.

The usual solutions for gum-bichromate or a gelatine-pigment composition may be used, but I prefer a starch-gum colloid, which gives a characteristic matt print, the paper being prepared in an insensitive state, and when required treated with a spirit sensitizer.

Select a tracing paper with as little a grain as possible, consistent with a good body of translucent material, taking care not to "kink" it. Some of the yellow paper (contrary to expectations) seem to give a finer quality print than the blue varieties. It does not follow that because a paper is very clear, the translucent material will remain until the print is dry, a fact that should be carefully considered.

THE COLLOID.

Take half a dram of white starch, mix with a little water to form a smooth paste, and add, with constant stirring, two ounces of boiling water, which should result in a clear liquid. Immediately this has taken place, add 3 drams of powdered gum arabic, which will give the working colloid.

The pigment may be tube water color or powder

color, the latter in my hands being the more satisfactory. The amount of pigment will vary with the color, but as a suggestion take:

Gum starch colloid 1 dram.
Brown pigment (dry) 5 grains.

Mix well upon a slab of ground glass or opal with a palette knife. When thoroughly mixed, sheets of tracing paper may be coated with a flat brush, softened after the manner of a gum print, if necessary (but probably not), and hung up to dry. A thin coating with a fair body is quite sufficient, and, of course, very much thinner, indeed, than the coating on carbon tissue.

The stock sensitizer may be prepared as follows:

Ammonium bichromate 92 grs.
Soda carbonate 15 grs.
Water 3½ ozs.

The dry paper should be pinned down, pigment side up, upon a sheet of blotting-paper, and a mixture of one part of the bichromate solution with two parts of methylated spirit should be lightly brushed over the surface, the paper then being hung up in a warm place away from light, when it will be dry in a few minutes.

A carbon-quality negative will give quite good prints. Printing should be carried out upon the uncoated side of the paper, using an actinometer in a similar manner to carbon. Development takes place in a bath of tepid water, after soaking the print a little in cold water and giving it a start in development in water fairly hot, the latter being a necessary procedure with the starch-gum colloid. The best results are obtained by rocking the dish, splashing water upon the face of the print, tending to hardness. The print will need

to be examined upon a piece of opal glass from time to time, and when satisfactory may be alumed, washed, and dried. The dry print may be mounted by the dry-mounting process upon a suitable thick paper base, afterward trimming. A very little practice will secure prints of uniform excellence, far away ahead of gum prints, made by exposing from the film side.

It will be obvious that the paper base affords very considerable control in washes of Indian ink or color; before the print is finally laid down upon it, some very rich shadows and extra tone in backgrounds are not at all difficult to work in, the limit of control (not be it remembered, upon the print itself), being the extent With regard to the preparation of the reversed negative, for non-reversed finished prints, the formula, of M. Maes may be recommended.

A slow plate should be exposed behind the negative for a sufficient time to give a transparency of full vigor through the plate. The plate is developed in a non-staining developer, washed, and in its unfixed state brought into full daylight, the white parts then taking a slight violet tint. Returning to the dark-room the plate is flooded with the reversing solution,

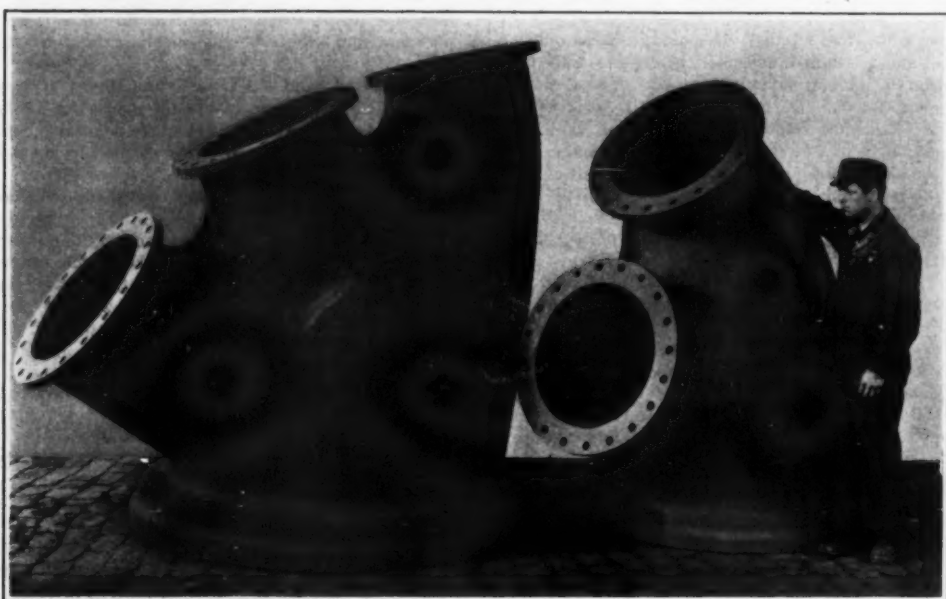
Potassium bichromate 225 grs.
Nitric acid 1½ drs.
Water 18 ozs.

when, after bleaching, the plate is washed, re-developed in the same bath as used for the first development, washed, fixed, washed, and dried, the result being a negative reversed, as regards right and left, being made in less time almost than it takes to recite the procedure.

—The British Journal of Photography.

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Three Cast-iron Bell-end Fittings Having a Combined Weight of 19,150 Pounds.

Large Gate Valves and Pump Fittings

Representative of Modern Mammoth Construction

Our frontispiece shows one of four large gate valves recently shipped by a well-known firm of Bridgeport, Connecticut, to a Canadian Colliery at Union Bay, B. C., to be used in connection with a hydro-electric plant there.

The valves consisted of two 72-inch and two 50-inch standard iron body taper seat wedge gate valves with by-passes and spur gears.

While such large valves are most commonly supplied for low-pressure work, the 72-inch on this order will be used under a hydraulic working load of 125 pounds, and the 50-inch under a load of 165 pounds per square inch. They are massively constructed and have a large factor of safety, although built to retain as graceful lines as possible in such large castings.

The two mammoth 72-inch valves weigh 51,020 pounds and 49,080 pounds net each, respectively, averaging just about twenty-five tons apiece, this being about six tons heavier each than the low-pressure type. Of the two valves, the heavier, which was built to sustain a somewhat more severe strain than its companion, was tested to 240 pounds working pressure, and the other was tested to 175 pounds pressure by the customer's inspectors. Both 50-inch valves, which weighed 20,010

pounds each, were subjected to tests of 240 pounds.

As will be noticed by the illustration, the 72-inch valves are of a new type, having two bronze spindles, upon which the huge gates weighing $4\frac{1}{2}$ tons may be readily raised and lowered by the 42-inch hand wheel operating in connection with the gears. The gates are bronze faced and travel on bronze rollers upon bronze tracks in the valve body. This is also the method of operating the 50-inch valves, although they are equipped with single spindles and have steel rollers.

Other interesting dimensions of the 72-inch valves are: extreme height, 17 $\frac{1}{2}$ feet; face to face, 48 inches; diameter of flanges, 87 inches; size of by-pass, 10 inches. The 50-inch stand, 13 $\frac{1}{2}$ feet high; face to face, 38 inches; diameter of flanges, 62 inches; size of by-pass, 8 inches.

On all four valves, the by-passes are operated by long steel stems extending so that their hand wheels are even with the larger hand wheels and can be conveniently reached.

In shipping the valves across the continent, the 72-inch occupied a flat car apiece, while the two 50-inch went forward on another.

The illustrations on this page, reproduced by

courtesy of the editor of the *Valve World*, show three special discharge fittings for pumps, manufactured by the same firm for an irrigation company of Idaho.

The three cast-iron bell-end fittings have a combined weight of 19,150 pounds, the largest one weighing 10,850 pounds, the smallest one 4,100 pounds, and the third, 4,200 pounds.

The dimensions are, respectively: 5 feet with three 24-inch flanged outlets; 4 feet 4 $\frac{1}{2}$ inches with two 24-inch flanged outlets; and 3 feet 10 inches with two 18-inch flanged outlets.

The fittings connect at the bell-end to wood pipe and at the flanged ends to spiral steel pipe penstocks. The largest fittings will work under a static head of 159 feet, the next in size under a head of 89 feet, and the smallest under a head of 54 feet.

The work being done on this power and irrigation project is of the highest order, the object of the company and engineers being to make it one of the best and most efficient plants of the kind in the country. The nature of the country is wild and most uneven, and consequently some interesting and uncommon pipe, valve, and fittings installations mark the steady progress of the work.

Facts and Fancy About Ventilation—II*

Chemical Composition of the Air an Imperfect Criterion of Its Health Value

By Leonard Hill, M.B., F.R.S.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 1926, Page 339, November 30, 1912

Experimental evidence is strongly in favor of my argument that the chemical purity of the air is of no importance. Analyses show that the oxygen in the worst-ventilated school-room, chapel, or theater is never lessened by more than 1 per cent of an atmosphere; the ventilation through chink and cranny, chimney, door, and window, and the porous brick wall, suffices to prevent a greater diminution. So long as there is present a partial pressure of oxygen sufficient to change the hæmoglobin of the venous blood into oxyhæmoglobin there can arise no lack of oxygen.

At sea-level the pressure of oxygen in the pulmonary alveolar air is about 100 millimeters Hg. Exposed to only half this pressure the hæmoglobin is more than 80 per cent saturated with oxygen.

In noted health-resorts of the Swiss Mountains the barometer stands at such a height that the concentration of oxygen is far less than in the more ventilated room. On the high plateau of the Andes there are great cities: Potosi with a hundred thousand inhabitants is at 4,165 meters, and the partial pressure of oxygen there is about 13 per cent of an atmosphere in place of 71 per cent at sea-level; railways and mines have been worked up to altitudes of 14,000 to 15,000 feet. At Potosi girls dance

half the night, and treadingers display their skill in the ring. On the slopes of the Himalayas shepherds take their flocks to altitudes of 18,000 feet. No disturbance is felt by the inhabitants or those who reach these great altitudes slowly and by easy stages. The only disability to a normal man is diminished power for severe exertion, but a greater risk arises from want of oxygen to cases of heart disease, pneumonia, and in chloroform anesthesia at these high altitudes. The newcomer who is carried by the railway in a few hours to the top of Pike's Peak or the Andes may suffer severely from mountain sickness, especially on exertion, and the cause of this is want of oxygen. Acclimatization is brought about in a few days' time. The pulmonary ventilation increases, the bronchial tubes dilate, the circulation becomes more rapid. The increased pulmonary ventilation lowers the partial pressure of carbon dioxide in the blood and pulmonary air, and this contributes to the maintenance of an adequate partial pressure of oxygen. Haldane and Douglas say that the percentage of red corpuscles and total quantity of the hæmoglobin increases, and maintain that the oxygen is actively secreted by the lung into the blood, but the CO method by which their determinations have been made has not met with unqualified acceptance. If waste products, which arise from oxygen want,

alter the combining power of hæmoglobin, this alteration may not persist in shed blood; for these products may disappear when the blood is exposed to air. Owing to the combining power of hæmoglobin the respiratory exchange and metabolism of an animal within wide limits are independent of the partial pressure of oxygen. On the other hand, the process of combustion is dependent not on the pressure, but on the percentage of oxygen. Thus the aeroplane pilot may become seized with altitude sickness from oxygen want, while his gas engine continues to carry him to loftier heights.

The partial pressure of oxygen in a mine at a depth of 3,000 feet is considerably higher than at sea level, and if the percentage is reduced to 17, while the firing of fire-damp and coal-dust is impossible, there need be in the alveolar air of the lungs no lower pressure of oxygen than at sea-level. Thus the simplest method of preventing explosions in coal mines is that proposed by J. Harger, viz., to ventilate them with air containing 17 per cent of oxygen.

There is little doubt that all the great mine explosions have been caused by the enforcement of a high degree of chemical purity of the air. In the old days when ventilation was bad there were no great dust explosions. Mr. W. H. Chambers, general manager of the Cadeby mine,

* Reproduced from *Nature*.

where the recent disastrous explosion occurred, with the authority of his great and long practical experience of fiery mines, told me that the spontaneous combustion of coal and the danger of explosion can be wholly met by adequate diminution in ventilation. The fires can be choked out while the miners can still breathe and work. The Coal Mine Regulation Act enforces that a place shall not be in a fit state for working or passing therein if the air contains either less than 19 per cent of oxygen, or more than $1\frac{1}{4}$ per cent of carbon dioxide. A mine liable to spontaneous combustion of coal may be exempted from this regulation by order of the Secretary of State.

The regulations impel the provision of such a ventilation current that the percentage of oxygen is sufficient for the spread of dust explosions along the intake airways, with the disastrous results so frequently recorded. If the mine were ventilated with air containing 17 per cent of oxygen in sufficient volume to keep the miners cool and fresh, not only would explosions be prevented, but the mines could be safely worked and illuminated with electricity, and miners' nystagmus prevented, for this is due to the dim light of the safety lamp. The problem possibly may be solved by purifying and cooling the return air, and mixing and circulating this with a sufficiency of fresh air.

Owing to the fact that the percentage of CO_2 is the usual test of ventilation and that only a very few parts per 10,000 in excess of fresh air are permitted by the English Factory Acts, it is generally supposed that CO_2 is a poison, and that any considerable excess has a deleterious effect on the human body. No supposition could be further from the truth.

The percentage of CO_2 in the worst ventilated room does not rise above 0.5 per cent, or at the outside 1 per cent. It is impossible that any excess of CO_2 should enter into our bodies when we breathe such air, for whatever the percentage of CO_2 in the atmosphere may be, that in the pulmonary air is kept constant at about 5 to 6 per cent of an atmosphere—by the action of the respiratory center. It is the concentration of CO_2 which rules the respiratory center, and to such purpose as to keep the concentration both in the lungs and in the blood uniform (Haldane); the only result from breathing air containing 0.5 to 1 per cent of CO_2 is an inappreciable increase in the ventilation of the lungs. The very same thing happens when we take gentle exercise and produce more CO_2 in our bodies.

By a series of observations made on rats confined in cages fitted with small, ill-ventilated sleeping-chambers, we have found that the temperature and humidity of the air—not the percentage of carbon dioxide or oxygen—determines whether the animals stay inside the sleeping-room or come outside. When the air is cold, they like to stay inside, even when the carbon dioxide rises to 4 or 5 per cent of an atmosphere. When the sleeping-chamber is made too hot and moist they come outside.

The sanitarian says it is necessary to keep the CO_2 below 0.01 per cent, so that the organic poisons may not collect to a harmful extent. The evil smell of crowded rooms is accepted as unequivocal evidence of the existence of such. He pays much attention to this and little or none to the heat and moisture of the air. The smell arises from the secretions of the skin, soiled clothes, etc. The smell is only sensed by and excites disgust in one who comes to it from the outside air. He who is inside and helps to make the "fogg" is both wholly unaware of, and unaffected by it. Flügge points out, with justice, that while we naturally avoid any smell that excites disgust and puts us off our appetite, yet the offensive quality of the smell does not prove its poisonous nature. For the smell of the trade or food of one man may be horrible and loathsome to another not used to such.

The sight of a slaughterer and the smell of dead meat may be loathly to the sensitive poet, but the slaughterer is none the less healthy. The clang and jar of an engineer's workshop may be unendurable to a highly-strung artist or author, but the artificers miss the stoppage of the noisy clatter. The stench of glue-works, fried-fish shops, soap and bone-manure works, middens, sewers, become as nothing to those engaged in such, and the lives of the workers are in no wise shortened by the stench they endure. The nose ceases to respond to the uniformity of the impulse, and the stench clearly does not betoken in any of these cases the existence of a chemical organic poison. On descending into a sewer, after the first ten minutes the nose ceases to smell the stench; the air therein is usually found to be far freer from bacteria than the air in a schoolroom or tenement.

If we turn to foodstuffs we recognize that the smell of alcohol and of Stilton or Camembert cheese is horrible to a child, while the smell of putrid fish—the meal of the Siberian native—excites no less disgust in an epicure, who welcomes the cheese. Among the hardiest and healthiest of men are the North Sea fishermen, who sleep in the cabins of trawlers reeking with fish and oil, and for the sake of warmth shut themselves up until the lamp may go out from want of oxygen. The stench of such surroundings may effectually put the sensitive,

untrained brain worker off his appetite, but the robust health of the fisherman proves that this effect is nervous in origin, and not due to a chemical organic poison in the air.

Ventilation cannot get rid of the source of a smell, while it may easily distribute the evil smell through a house. As Pottenkofer says, if there is a dunghill in a room, it must be removed. It is no good trying to blow away the smell.

Flügge and his school bring convincing evidence to show that a stuffy atmosphere is stuffy owing to heat stagnation, and that the smell has nothing to do with the origin of the discomfort felt by those who endure it. The inhabitants of reeking hovels in the country do not suffer from chronic ill-health, unless want of nourishment, open-air exercise, or sleep come into play. Town workers who take no exercise in the fresh air are pale, anemic, listless. Sheltered by houses they are far less exposed to winds, and live day and night in a warm, confined atmosphere.

In the modern battleship men are confined very largely to places artificially lit and ventilated by air driven in by fans through ventilating-shafts. The heat and moisture derived from the bodies of the men, from the engines, from cooking-ranges, etc., lead to a high degree of relative moisture, and thus all parts of the ironwork inside are coated with granulated cork to hold the condensed moisture and prevent dripping.

The air smells with the manifold smells of oil, cooking, human bodies, etc., and the fresh air driven in by fans through the metal conduits takes up the smell of these, and is spoken of by the officers with disparagement as "tinned" or "potted" air. This air is heated when required by being made to pass over radiators. Many of the officers' cabins and offices for clerks, typewriters, etc., in the center of a battleship, have no portholes, and are only lit and ventilated by artificial means. The steel nature of the structure prevents the diffusion of air which takes place so freely through the brick walls of a house. The men in their sleeping quarters are very closely confined, and as the openings of the air-conduits are placed in the roof between the hammocks, the men next to such openings receive a cold draught and are likely to shut the openings. To sleep in a warm moist "fogg" would not much matter if the men were actively engaged for many hours of the day on deck and there exposed to the open air and the rigors of sea and weather. In the modern warship most of the crew work for many hours under deck, and some of the men may scarcely come on deck for weeks or even months. Considering the conditions which pertain, it seems to be of the utmost importance that all the men in a battleship should be inspected at short intervals by the medical officers so that cases of tuberculosis may be weeded out in their incipency. The men of every rating should do deck drill for some part of every day. In the Norwegian navy every man, cooks and all, must do gymnastic drill on deck once a day. In the case of our navy, with voluntary service, the men should welcome this in their own interest.

I conclude, then, that all the efforts of the heating and ventilating engineer should be directed toward cooling the air in crowded places and cooling the bodies of the people by setting the air in motion by means of fans. In a crowded room the air confined between the bodies and clothes of the people is almost warmed up to body temperature and saturated with moisture, so that cooling of the body by radiation, convection and evaporation becomes reduced to a minimum. The strain on the heat-regulating mechanism tells on the heart. The pulse is accelerated, the blood is sent in increased volume to the skin, and circulates there in far greater volume, while less goes through the viscera and brain. As the surface temperature rises, the cutaneous vessels dilate, the veins become filled, the arteries may become small in volume, and the blood-pressure low, the heart is fatigued by the extra work thrown upon it. The influence of the heat stagnation is shown by the great acceleration of the pulse when work is done, and the slower rate at which the pulse returns to its former rate on resting.

The increased percentage of carbonic acid and diminution of oxygen which has been found to exist in badly ventilated churches, schools, theaters, barracks, is such that it can have no effect upon the incidence of respiratory disease and higher death-rate which statistical evidence has shown to exist among persons living in crowded and unventilated rooms. The conditions of temperature, moisture, and windless atmosphere in such places primarily diminish the heat loss, and secondarily the heat production, i. e., the activity of the occupants, together with total volume of air breathed, oxygen taken in and food eaten. The whole metabolism of the body is thus run at a lower plane, and the nervous system and tone of the body is unstimulated by the monotonous, warm, and motionless air. If hard work has to be done it is done under conditions of strain. The number of pathogenic organisms is increased in such places, and these two conditions run together—diminished immunity and increased mass influence of infecting bacteria.

We have very great inherent powers of withstanding exposure to cold. The bodily mechanisms become trained and set to maintain the body heat by habitual exposure to open-air life. The risk lies in overheating our dwellings and overclothing our bodies, so that the mechanisms engaged in resisting infection become enfeebled, and no longer able to meet the sudden transition from the warm atmosphere of our rooms to the chill outside air of winter.

As the prevention of spray (saliva) infection by ventilation is impossible in crowded places, it behooves us to maintain our immunity at a high level. We may seek to diminish the spray output of those infected with colds by teaching them to cough, sneeze, and talk with a handkerchief held in front of the mouth, or to stay at home until the acute stage is past.

In all these matters nurture is of the greatest importance, as well as nature. A man is born with physical and mental capacities small or great, with inherited characteristics, with more or less immunity to certain diseases with a tendency to longevity of life or the opposite, but his comfort and happiness in life, the small or full development of his physical and mental capacities, his immunity and his longevity of life, are undoubtedly determined to a vast extent by nurture.

The essentials required of any good system of ventilating are then (1) movement, coolness, proper degree of relative moisture of the air; (2) reduction of the mass influence of pathogenic bacteria. The chemical purity of the air is of very minor importance, and will be adequately insured by attendance to the essentials.

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Table of Contents

	PAGE
Modern Painting Methods in the Navy.—By Henry Williams	354
The Optics of a Railway Signal Lamp.—By T. A. Lawson.—13 Illustrations	355
The Use of Sulphur Dioxide in the Manufacture of Wines	355
Glasgow Main Drainage Scheme.—By Hon. Frank I. Cohen.—9 Illustrations	356
Some Recent Developments in Wood Distillation.—By Thomas W. Pritchard	358
Novelties at the Paris Aviation Show.—II.—18 Illustrations	360
Enzymes and Inhibitors.—By A. Hardens	363
A Gateway to the Heart of New York.—3 Illustrations	364
Some Experiments in Carbon Printing Without Transfer	366
Large Gate Valve and Pump Fittings.—3 Illustrations	367
Facts and Fancies About Ventilation.—II.—By Leonard Hill	367

ending
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bitual
eating
t the
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